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AIRBORNE ROTARY AIR SEPARATOR STUDY

FINAL REPORT CR-191045

Contract No. NAS3-25560-MOD 7

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ABSTRACT

Several air breathing propulsion concepts for future earth-to-orbit transport vehicles utilize air collection and enrichment, and subsequent storage of liquid oxygen for later use in the vehicle mission. Work performed during the 1960's established the feasibility of substantially reducing weight and volume of a distillation type air separator system by operating the distillation elements in high "g" fields obtained by rotating the separator assembly.

The purpose of this study was to evaluate various fuels and fuel combinations with the objective of minimizing the weight and increase the ready alert capability of the plane. Fuels will be used to provide energy as well as act as heat sinks for the on-board heat rejection system. Fuel energy was used to provide power for air separation as well as to produce refrigeration for liquefaction of oxygen enriched air, besides its primary purpose of vehicle propulsion. The heat generated in the cycle was rejected to the fuel and water which is also carried on board the vehicle. The fuels that were evaluated include JP4, methane and hydrogen. Hydrogen served as a comparison to the JP4 and methane cases.

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I. INTRODUCTION

This report covers the work done by **PRAXAIR, INC.** Linde Division on NASA Contract NAS3-25560 during the period of 2/90 - 9/92. Previous work dealt with the evaluation of "structured packing" for use in the on-board rotary air separator column as an improved mass transfer device. Ref. 1,2,3,4. The current study deals with the process to refrigerate the incoming air and reject the heat from the process.

Ready alert of the hypersonic plane is the key requirement for the U.S. Air Force. Liquid hydrogen fueled plane does not meet this requirement due to problems of logistics and supportability of the cryogenic hydrogen fuel. Non-cryogenic and preferably conventional fuels which lend themselves to the available airbase services were evaluated for the hypersonic plane application. The objective will be to provide the ready alert service while keeping the weight of the space plane as low as possible.

The purpose of this study was to evaluate various fuels and fuel combinations with the objective of minimizing the weight and increase the ready alert capability of the plane. Fuels will be used to provide energy as well as act as heat sinks for the on-board heat rejection system. Fuel energy was used to provide power for air separation as well as to produce refrigeration for liquefaction of oxygen enriched air, besides its primary purpose of vehicle propulsion. The heat generated in the cycle was rejected to the fuel and water which is also carried on board the vehicle. The fuels that were evaluated include JP4, methane and hydrogen. Hydrogen served as a comparison to the JP4 and methane cases.

The process study entailed detailed process evaluation for air separation, enriched air liquefaction and overall heat rejection. Computer modeling was used to simulate the process. Various heat rejection schemes were evaluated with respect to different temperatures and pressure levels. Process diagrams and heat and mass balances are provided for all the cases. Rough weight estimates were made on all cases.

II. BACKGROUND

Earlier efforts by Linde (Ref. 3) involved reviewing the results of 1960's work, reporting the results of the studies, and examining the potential impact of the advancements made during the last 21 years. This was documented and presented to the Air Force personnel in February 1988. It clearly indicated that the concept of compact rotating distillation air separators was feasible and that volume and weight, which were compatible or even better than the 1960's aerospace vehicle requirements could be achieved. Our study of the impact of the new technologies has shown that the advances have the potential to make the process more efficient, provide lower pressure drops, simplify the device mechanically and lead to substantial weight and volume reduction. Of the different components and subsystems, the study indicated that the biggest impact on the system weight and volume should come through the use of structured packing Figure 1 in place of the conventional sieve trays in the rotating distillation column, Figure 2. In addition, the study has shown the potential for substantial flexibility in the selection of operating conditions and the possibility for respectable performance at turndown conditions with the use of structured packing, Figure 3. This should allow air collection and enrichment over a broader operating range of the vehicle, Figure 4 and thus help further reduce the air separator and liquefier size and weight.

In previous studies, Ref. 4, the rotary separator using structured packings was tested using air and water and shown to have the necessary through put and its weight was estimated at 8100 lbs. The current study analyzes the refrigeration system necessary to liquify and separate 512 lbs/sec of liquid at 87.4% O_2 purity using JP-4 fuel and water, liquid methane and water and liquid hydrogen as fuel for the vehicle and as a heat sink for the process.

III. PROCESS STUDY

A detailed cycle analyses has been performed on the refrigeration system to produce 512 lbs/sec of liquid at 87.4% O₂ concentration on board an aircraft. Three cases were studied using water/ice slush with JP-4 as fuel and two using liquid methane with and without slush and one using liquid hydrogen as fuel. The analysis was broken into two parts for all cases except hydrogen. The incoming air is first cooled from 1300 R to 530 R using water and then further cooled, separated and liquified in a cryogenic system. In the hydrogen case, sufficient refrigeration exists in the hydrogen stream to cool and liquify the incoming air. In the best case using liquid methane as fuel the system produces 1.84 lb LEA/lb water, and requires 118,350 lbs of heat exchanger, 556,822 kw of net power supplied by a 178,200 lb gas turbine and four expansion turbines totaling 9,800 lbs and two compressors totaling 64,400 lbs. The total equipment weight is 378,860 lbs and requires 333,300 lbs of water for 20 minutes of liquid production. The large equipment weights are a result of the large recycle flows, 8,946,000 lb/hrs required to heat pump 254×10^6 Btu/hr from 175° R to 530° R.

Tables 1 and 2 provide weight summaries of the six cryogenic liquefaction cases and the air cooling case under a high overall heat transfer assumption (high U) and a low heat exchanger pressure drop of 0 to 2 psi, Table 1, and a low overall heat transfer assumption (low U) and low heat exchanger pressure drop, Table 2.

The higher U reduces the heat exchanger weight by about 60% but to achieve the higher U a gas side pressure drops on the order of 20 psi would be required. This in turn would require higher recycle flows, larger compressors, drivers and expanders. This optimization was not carried out.

Comparison with Allied-Signal AiResearch (5) air liquefaction heat exchanger work for an air precooled, the overall U was 150 Btu/HrFt²° F for an H₂ to air heat exchanger but the air side pressure drop was 34 psi and the H₂ side pressure drop was 40 psi. The heat exchanger average tube weight was 23 ft²/lb if a factor of 2 for wrap-up is used the

overall weight would be 11.5 ft²/lb. This compares well with the assigned weight of 12 ft²/lb used in this study.

The detailed process flow charts and stream properties are given in the appendix. The process calculations were performed using the CHEMCAD process simulation program. The assumptions which were used to estimate the weights from the cycle powers and heat exchanger duties are given in Table 3.

The second largest weights are in the heat exchangers. They were sized using aggressive heat transfer coefficients, Table 3, to calculate the required areas. The weights were then calculated using 12 ft²/lb for 1/8" OD x .003" wall aluminum tube heat exchangers (IBT-1). The core density for just the heat exchanger tubes is 6.79 lb/ft³ and assuming a factor of 2 for wrap-up, the complete heat exchanger weight is 13.58 lb/ft³. The area density is 161 ft²/ft³ which results in a specific area of ~ 12 ft²/lb.

The compressor, gas turbine driver and expanders are all scaled on a kilowatt bases from a GE LM-6000 gas turbine. This machine weighs .32 lb/kw. The compressors and expanders are sized at .1 lb/kw or 1/3 of the total gas turbine weight. This weight is very aggressive compared to stationary equipment which would be 10 times heavier.

The use of 50% solid slush water at 32 F results in additional refrigeration of 110 btu/lb of on-board water. Of this 72. btu/lb of water is from the heat of fusion of the ice and 38. btu/lb is from the use of colder (32 F) water. This results in a 13% increase in the cooling capacity of the water. This was simulated in the program by assuming all the water was liquid at -40 F.

The JP-4 liquefaction cycles run were as follows:

Case 1 has a refrigeration loop pressure of 450 psia discharge and 47 psia suction. Case 2 has a refrigeration loop pressure of 450 psia discharge and 27 psia suction. Case 3 has a refrigeration loop pressure of 1500 psia discharge and 27 psia suction. The

equipment weight ranges from 361,420 to 512,253 lbs with Table 1, Case 1 having the minimum weight. Slush use is about 1,000,000 lbs/hr. In these cases the equipment weight or water usage changed only by 20% to 30% as the recycle pressures were varied.

The liquid methane fuel cycle, Table 1, Case 4, and Case 5 results in significant reductions in both the water and equipment weights due to the lower temperature and greater refrigeration compared to JP-4. The enthalpy change of methane is 405 btu/lb starting at -259 to 100 F compared to 313 btu/lb starting at 70 to 440 F. The liquid methane, case 5, requires 321,000 lbs of equipment and no cooling water for the cryogenic part of the cycle. Compared to the methane Case 4, the water was removed from the cycle by increasing the recycle flow, this in turn, increased the size of the compressor and driver. The net result was saving of 27,000 lbs.

All the cryogenic refrigeration and liquefaction cycles have the incoming 840 F air cooled to 70 F. This is carried out in a separate system which was designed by Mr. W. Bond formerly at Rockwell and further modified by Linde. The system uses water slush which is split into a low pressure and high pressure stream to cool the air which is also split into two streams. The low pressure water stream is then compressed from .26 psia to 16 psia and rejected as waste. The high pressure water stream is expanded to 16 psia, its heat exchanged with the hot air and then rejected as waste. The system weight is 57,900 lbs and it requires 1,000,000 lbs/hr of slush to process 7,735,000 lb/hr of air. The weight summary is shown in Table 1 and the process diagram and stream properties are in the appendix.

In the liquid hydrogen case, Table 1 and 2, Case 6, the weights are significantly reduced due to the large enthalpy change, 3900 Btu/lb, of the hydrogen stream compared to only 591 Btu/lb for liquid methane. The hydrogen case requires only 73,000 lbs of equipment and no additional water cooling. The hydrogen case is not surprising and is also not optimized. It serves as a check on the methods and modeling performed in the other cases.

IV. CONCLUSION

In general even though the cycles are not optimized for minimum weight, the best, Case 5, using liquid methane with high U, low pressure drop heat exchangers, is worse than loading the LO₂ on board before take-off. In a 20 minute production period, 536,900 lbs of LO₂ is collected, but this requires at take-off 333,000 lbs of slush and 379,000 lbs of equipment. The total weight at take-off of the air separation system is 712,000 lbs to produce 536,900 lbs of LO₂.

ACKNOWLEDGMENT

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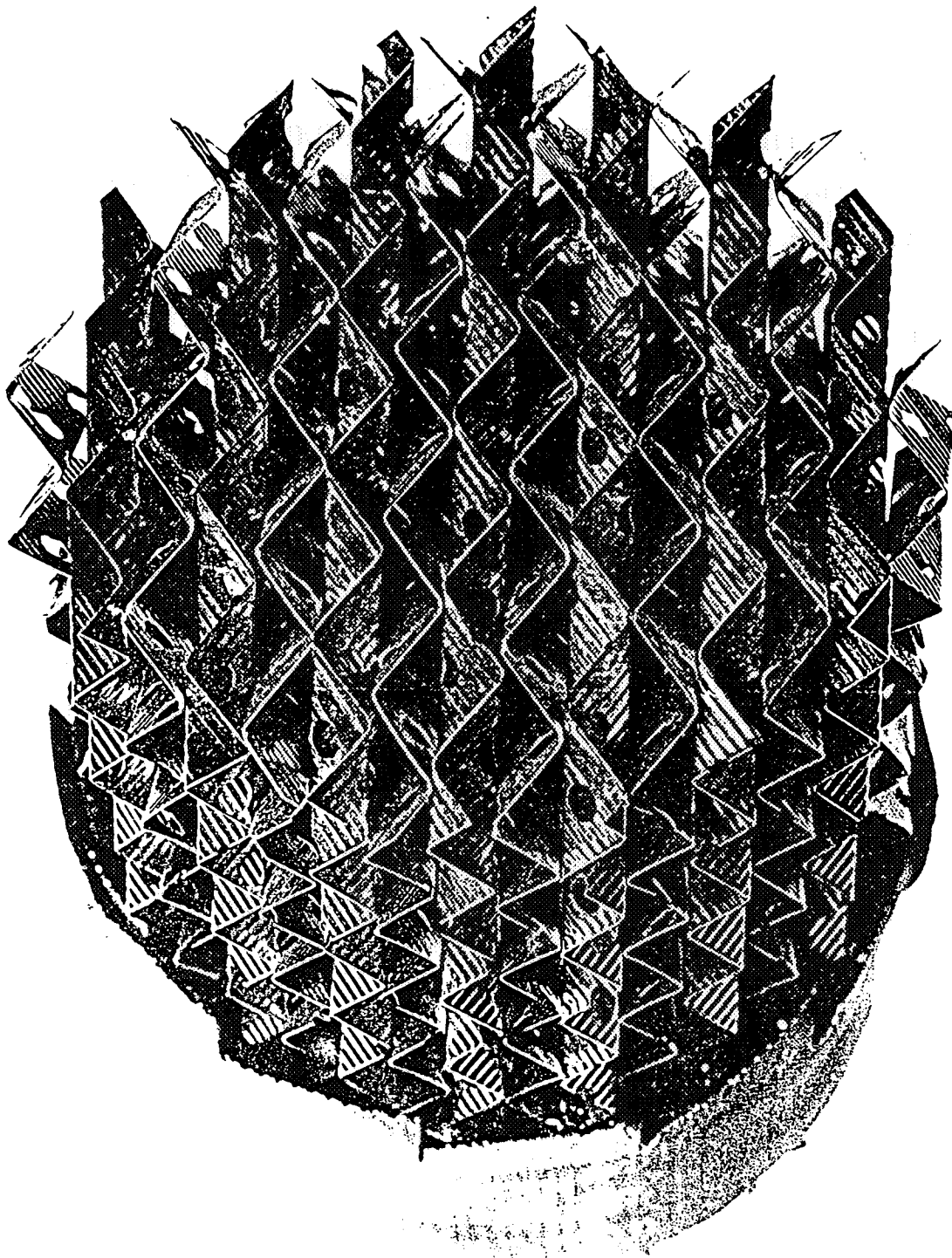
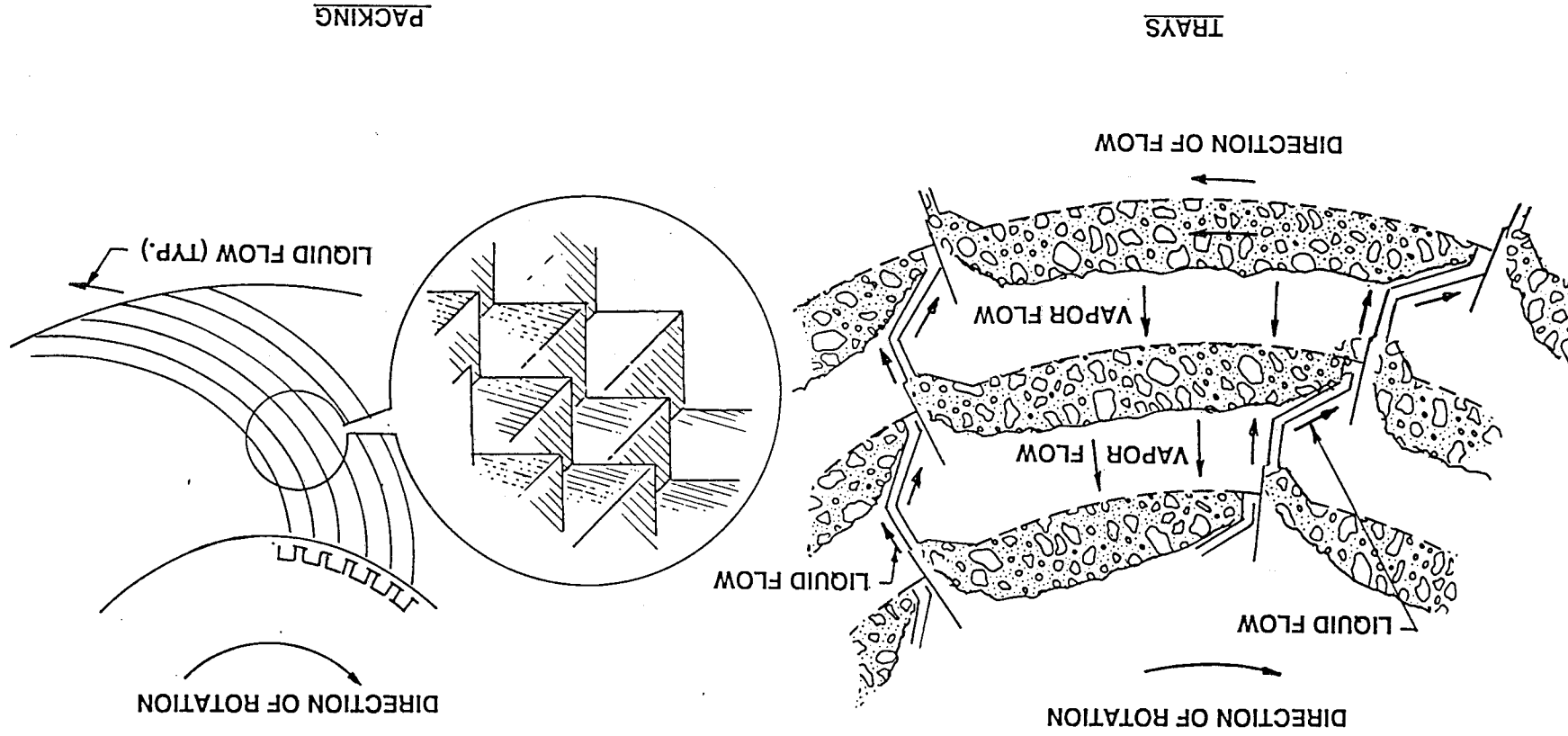


FIGURE 1
STRUCTURED PACKING

FIGURE 2
ROTATING COLUMN



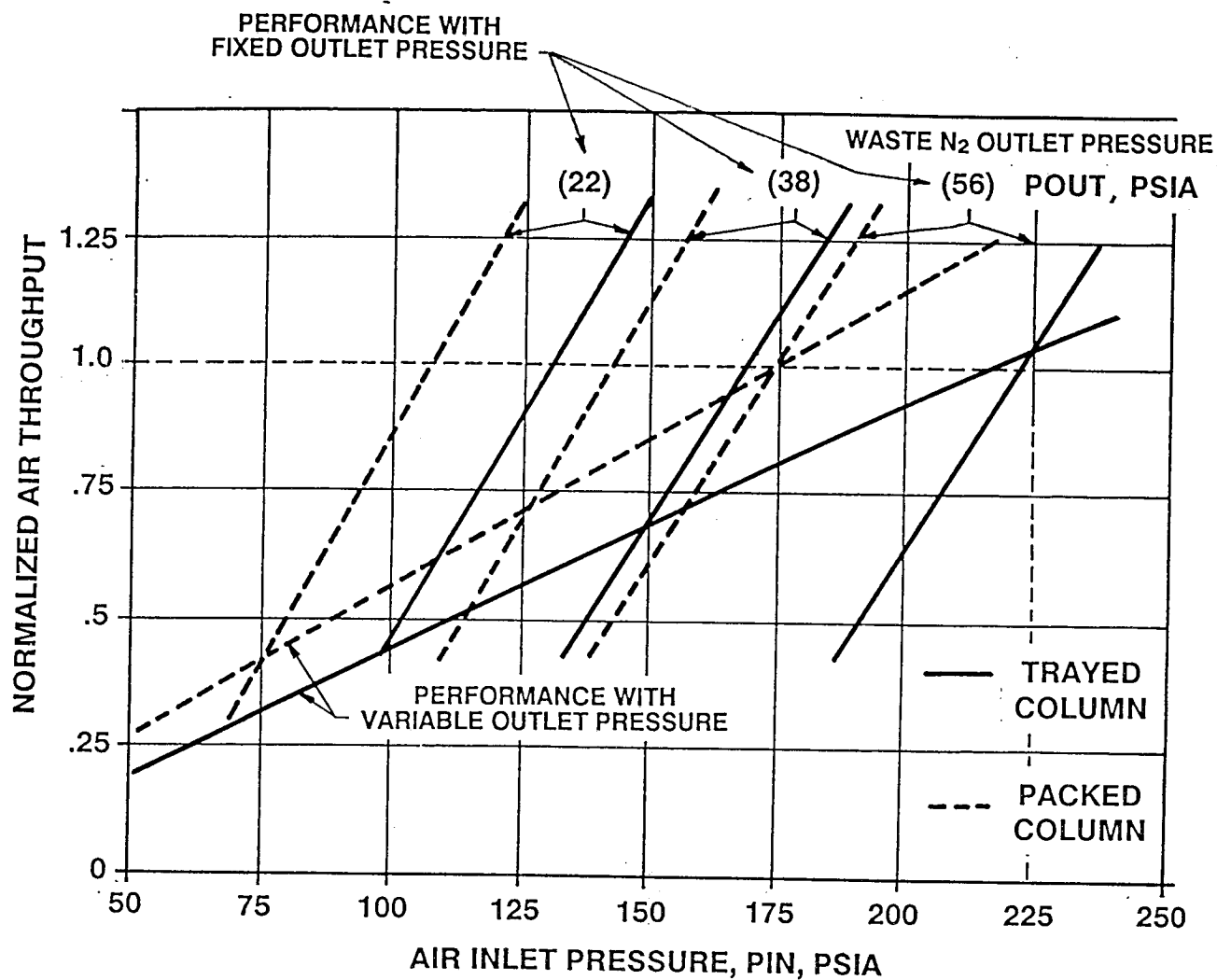


FIGURE 3
AIR SEPARATOR SYSTEM TURNDOWN
PERFORMANCE PROJECTION

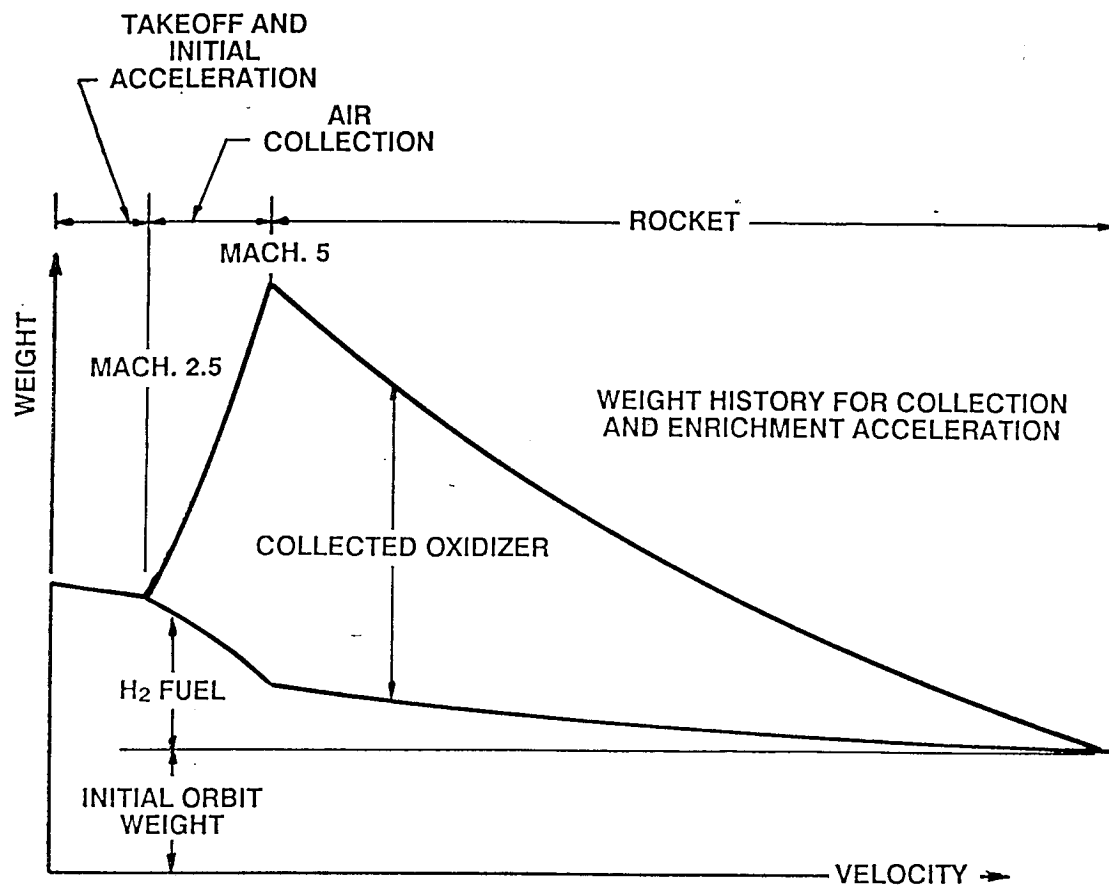


FIGURE 4
TYPICAL CHARACTERISTICS OF ACES SYSTEM

TABLE 1 WEIGHT SUMMERY - HIGH U AND LOW PRESSURE DROP CASE

CRYOGENIC REFRIGERATION AND LIQUEFACTION CYCLE							AIR COOLING CYCLE SLUSH
COOLANT	CASE 1 JP-4/SLUSH	CASE 2 JP-4/SLUSH	CASE 3 JP-4/SLUSH	CASE 4 LCH4/SLUSH	CASE 5 LCH4 ONLY	CASE 6 HYDROGEN	
RECYCLE LOOP PRESSURES	450 PSIA TO 47 PSIA	450 PSIA TO 27 PSIA	1500 PSIA TO 26 PSIA	425 PSIA TO 49 PSIA	425 PSIA TO 49 PSIA	NA	NA
HX FT ^ 2	1,347,042	1,387,132	1,153,118	1,147,378	1,051,525	768,403	368,737
HX WT. - LBS @12 FT ^ 2/LB	112,254	115,594	96,093	95,615	87,627	64,034	30,728
COMPRESSOR POWER KW	653,521	530,400	1,060,000	365,944	558,331	NA	85,718
FLOW - LBS/HR	15,347,000	12,900,000	12,000,000	8,210,000	8,945,724	NA	550,000
MACHINE WT. - LBS @ .1LB/KW	65,352	53,040	106,000	36,594	55,833	NA	8,572
EXPANDERS							
POWER - KW	4,639	5,613	3,530	1,477	1,524	9,411	48,621
FLOW - LBS/HR	3,353,000	3,350,000	3,360,000	3,290,000	3,396,805	5,889,000	450,000
MACHINE WT. - LBS @ .1LB/KW	464	561	353	148	152	941	4,862
POWER - KW	81,098	62,280	125,483	38,611	38,611		
FLOW - LBS/HR	8,157,000	5,029,000	7,440,000	4,930,000	5,095,193		
MACHINE WT. - LBS @ .1LB/KW	8,110	6,228	12,548	3,861	3,861		
POWER - KW	81,284	108,511	33,756	9,412	9,412		
FLOW - LBS/HR	3,837,000	4,514,000	1,200,000	5,890,000	6,065,353		
MACHINE WT. - LBS @ .1LB/KW	8,128	10,851	3,376	941	941		
POWER - KW	11,099	11,123	11,113				
FLOW - LBS/HR	5,889,000	5,889,000	5,900,000				
MACHINE WT. - LBS @ .1LB/KW	1,110	1,112	1,111				
POWER - KW			11,398				
FLOW - LBS/HR			3,360,000				
MACHINE WT. - LBS @ .1LB/KW			1,140				
GAS TURBINE DRIVER							
NET POWER - KW	493,445	530,360	889,600	321,500	513,891	NA	42,931
WEIGHT @.32 LB/KW	157,902	169,715	284,672	102,880	164,445	NA	13,738
ROTARY AIR SEPARATOR WT. - LBS	8,100	8,100	8,100	8,100	8,100	8,100	
COOLING WATER LBS./HR.	1,000,000	1,000,000	1,200,000	300,000	NA	NA	1,000,000
SYSTEM EQUIP. WT. -LBS	361,420	365,202	512,253	248,139	320,960	73,075	57,900
WATER SLUSH - LBS LO2/LBS SLUSH	1.61	1.61	1.34	5.37	NA	NA	1.61
WATER SLUSH - LBS LEA/LBS SLUSH	1.84	1.84	1.54	6.14	NA	NA	1.84
TOTAL SLUSH WATER REQ. - LB/HR	2,000,000	2,000,000	2,200,000	1,300,000	1,000,000	NA	
LBS LO2/LBS SLUSH	0.81	0.81	0.73	1.24	1.61	NA	
LBS LEA/LBS SLUSH	0.92	0.92	0.84	1.42	1.84	NA	
TOTAL EQUIPMENT WT. - LBS.	419,320	423,102	570,153	306,039	378,860	73,075	

TABLE 2 WEIGHT SUMMERY - LOW U AND LOW PRESSURE DROP CASE

CRYOGENIC REFRIGERATION AND LIQUEFACTION CYCLE

COOLANT	CASE 1 JP-4/SLUSH	CASE 2 JP-4/SLUSH	CASE 3 JP-4/SLUSH	CASE 4 LCH4/SLUSH	CASE 5 LCH4 ONLY	CASE 6 HYDROGEN	AIR COOLING CYCLE SLUSH
RECYCLE LOOP PRESSURES	450 PSIA TO 47 PSIA	450 PSIA TO 27 PSIA	1500 PSIA TO 26 PSIA	425 PSIA TO 49 PSIA	425 PSIA TO 49 PSIA	NA	NA
HX FT ²	3,295,222	3,418,431	2,737,864	2,515,707	2,395,902	1,917,643	855,048
HX WT. - LBS @12 FT ² /LB	274,602	284,869	228,155	209,642	199,659	159,804	71,254
COMPRESSOR POWER KW	653,521	530,400	1,060,000	365,944	558,331	NA	85,718
FLOW - LBS/HR	15,347,000	12,900,000	12,000,000	8,210,000	8,945,724	NA	550,000
MACHINE WT. - LBS @ .1LB/KW	65,352	53,040	106,000	36,594	55,833	NA	8,572
EXPANDERS							
POWER - KW	4,639	5,613	3,530	1,477	1,524	9,411	48,621
FLOW - LBS/HR	3,353,000	3,350,000	3,360,000	3,290,000	3,396,805	5,889,000	450,000
MACHINE WT. - LBS @ .1LB/KW	464	561	353	148	152	941	4,862
POWER - KW	81,098	62,280	125,483	38,611	38,611		
FLOW - LBS/HR	8,157,000	5,029,000	7,440,000	4,930,000	5,095,193		
MACHINE WT. - LBS @ .1LB/KW	8,110	6,228	12,548	3,861	3,861		
POWER - KW	81,284	108,511	33,756	9,412	9,412		
FLOW - LBS/HR	3,837,000	4,514,000	1,200,000	5,890,000	6,065,353		
MACHINE WT. - LBS @ .1LB/KW	8,128	10,851	3,376	941	941		
POWER - KW	11,099	11,123	11,113				
FLOW - LBS/HR	5,889,000	5,889,000	5,900,000				
MACHINE WT. - LBS @ .1LB/KW	1,110	1,112	1,111				
POWER - KW			11,398				
FLOW - LBS/HR			3,360,000				
MACHINE WT. - LBS @ .1LB/KW			1,140				
GAS TURBINE DRIVER							
NET POWER - KW	493,445	530,360	889,600	321,500	513,891	NA	42,931
WEIGHT @.32 LB/KW	157,902	169,715	284,672	102,880	164,445	NA	13,738
ROTARY AIR SEPARATOR WT. - LBS	8,100	8,100	8,100	8,100	8,100	8,100	
COOLING WATER LBS./HR.	1,000,000	1,000,000	1,200,000	300,000	NA	NA	1,000,000
SYSTEM EQUIP. WT. - LBS	523,768	534,477	644,316	362,167	432,991	168,845	98,426
WATER SLUSH - LBS LO2/LBS SLUSH	1.61	1.61	1.34	5.37	NA	NA	1.61
WATER SLUSH - LBS LEA/LBS SLUSH	1.84	1.84	1.54	6.14	NA	NA	1.84
TOTAL SLUSH WATER REQ. - LB/HR	2,000,000	2,000,000	2,200,000	1,300,000	1,000,000	NA	
LBS LO2/LBS SLUSH	0.81	0.81	0.73	1.24	1.61	NA	
LBS LEA/LBS SLUSH	0.92	0.92	0.84	1.42	1.84	NA	
TOTAL EQUIPMENT WT. - LBS.	622,194	632,903	742,741	460,592	531,417	168,845	

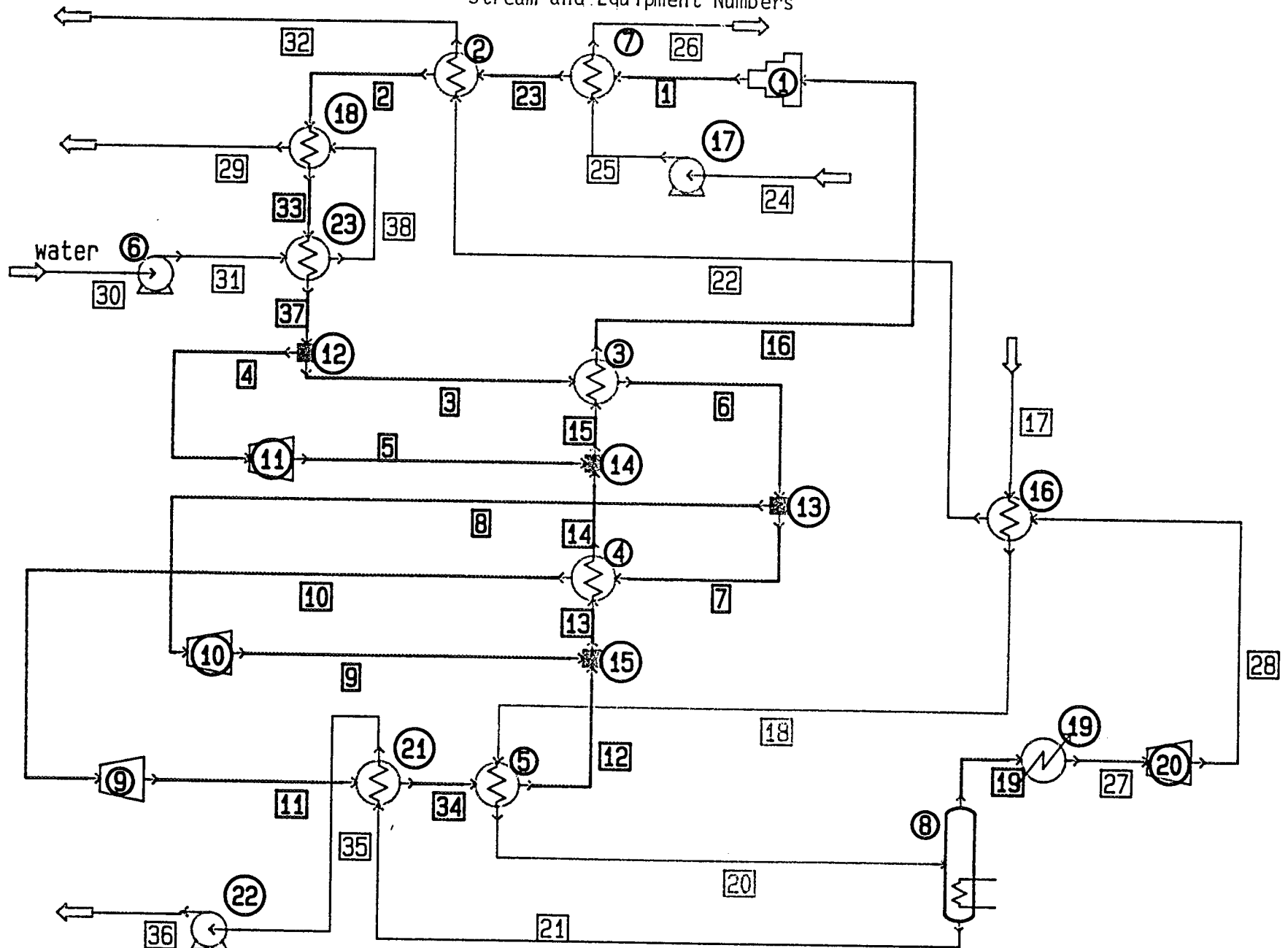
TABLE 3 – CYCLE ASSUMPTIONS

GAS TURBINE WEIGHT	.32 LB/KW	BASED ON GE LM-6000
COMPRESSOR WEIGHT	.1 LB/KW	BASED ON STRIPED GE LM-6000
COMPRESSOR EFFICIENCY	85%	
EXPANDER WEIGHT	.1 LB/KW	BASED ON STRIPED GE LM-6000
EXPANDER EFFICIENCY	90%	
HEAT EXCHANGER WEIGHT	12 FT ² /LB	BASED ON IBT-1, 1/8" OD x .003" WALL ALUMINUM TUBE HX
HX APPROACH TEMPERATURES	10 TO 50 DEG. F	
HX PRESSURE DROPS	0 TO 2 PSI	
HEAT TRANSFER COEFFICIENTS	LOW GAS SIDE COEFFICIENT	HIGH GAS SIDE COEFFICIENT
VAPOR TO VAPOR	20 BTU/HR-FT ² -F	50 BTU/HR-FT ² -F
VAPOR TO LIQUID	30 BTU/HR-FT ² -F	70 BTU/HR-FT ² -F
VAPOR TO BOILING	50 BTU/HR-FT ² -F	100 BTU/HR-FT ² -F
BOILING TO CONDENSING	1400 BTU/HR-FT ² -F	1400 BTU/HR-FT ² -F
LIQUID TO LIQUID	100 BTU/HR-FT ² -F	100 BTU/HR-FT ² -F
HEAT SINKS		
WATER/ICE SLUSH	50% SOLID	
ICE HEAT OF FUSION	143.5 BTU/LB	
JP-4 ENTHALPY CHANGE	313 BTU/LB BETWEEN 70 AND 440 F	
AIR INLET TO PRECOOLER	840 F AND 150 PSIA	
AIR INLET TO CRYOGENIC SYSTEM	70 F AND 150 PSIA	
ALL WASTE STREAMS EXIT PRESSURE	16 PSIA	
AIR COLLECTION RATE	513 LBS/S AT 87.3 MOLE % OXYGEN	
FUEL CONSUMPTION	200 LBS/S	

APPENDIX – CASES 1 TO 7

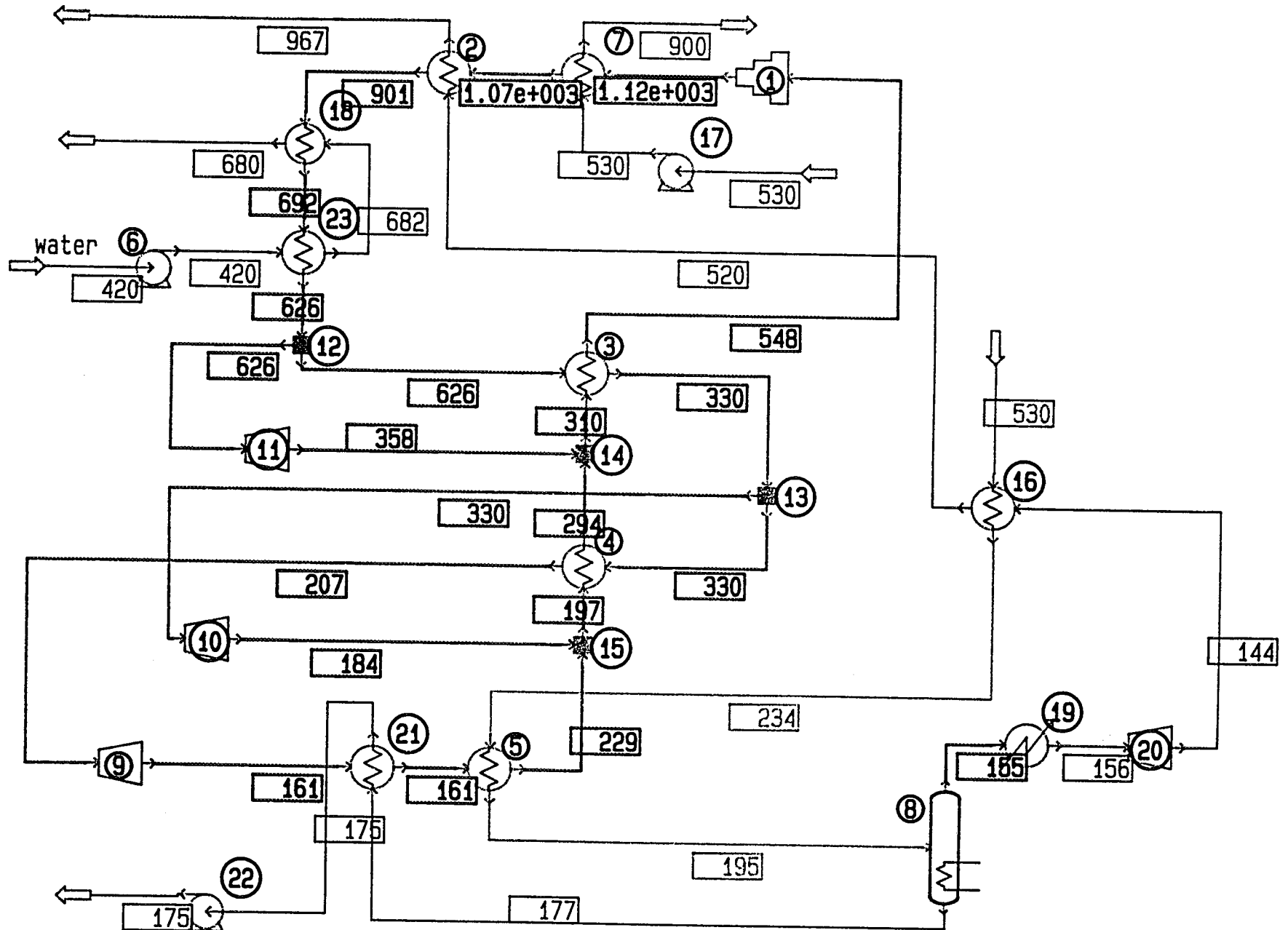
CASE 1

JP-4/Slush Cycle
Recycle Pressure 450 to 47 PSIA
Stream and Equipment Numbers



CASE 1

JP-4/Slush Cycle
Recycle Pressure 450 to 47 PSIA
Stream Temperatures



Filename : LIN500.TLK

Date: 9-Apr-92 Time: 8:36 am

SINGLE COMPRESSOR AND THREE EXPANDERS

FLOWSHEET SUMMARY

Equipment	Stream Numbers			
1 COMP	16	-1		
2 HTXR	23	22	-2	-32
3 HTXR	3	15	-6	-16
4 HTXR	7	13	-10	-14
5 HTXR	34	18	-12	-20
6 PUMP	30	-31		
7 HTXR	1	25	-23	-26
8 CSEP	20	-19	-21	
9 EXPN	10	-11		
10 EXPN	8	-9		
11 EXPN	4	-5		
12 DIVI	37	-4	-3	
13 DIVI	6	-8	-7	
14 MIXE	14	5	-15	
15 MIXE	12	9	-13	
16 HTXR	28	17	-22	-18
17 PUMP	24	-25		
18 HTXR	38	2	-29	-33
19 HTXR	19	-27		
20 EXPN	27	-28		
21 HTXR	11	21	-34	-35
22 PUMP	35	-36		
23 HTXR	31	33	-38	-37

Stream Connections

Stream	Equipment		Stream	Equipment		Stream	Equipment	
	From	To		From	To		From	To
1	1	7	14	4	14	27	19	20
2	2	18	15	14	3	28	20	16
3	12	3	16	3	1	29	18	
4	12	11	17		16	30		6
5	11	14	18	16	5	31	6	23
6	3	13	19	8	19	32	2	
7	13	4	20	5	8	33	18	23
8	13	10	21	8	21	34	21	5
9	10	15	22	16	2	35	21	22
10	4	9	23	7	2	36	22	
11	9	21	24		17	37	23	12
12	5	15	25	17	7	38	23	18
13	15	4	26	7				

Recycle Sequence

23 12 11 14 3 13 10 15 4 9 21 5 8 19 20 16 1

Recycle Sequence

7 2 18

Cut Streams

33 14 12 18 21

Accelerated Streams

33 14 12 18 21

Dominant Eigenvalue Method, frequency = 4

Recycle calculations have converged

COMPONENTS

46 47 62 39 98

THERMODYNAMICS

K-value model :Peng-Robinson

Enthalpy model :Peng-Robinson

Liquid density :API

Water miscible

Divider Summary

Equipment name	12	13
number		
Mode	0	1
	Ratio	lbmol/hr
Flow rate/ratio	0.250000	0.000000E+00
Flow rate/ratio	0.750000	119693.

Component Separator Summary

Equipment name	
number	8
P out / del P psia	35.0000
Top temp. mode	2
	Dew point
Top spec. value R	
Bottom temp. mode	2
	Dew point
Bottom spec. value R	
Component split mode	1
Split destination	Bottom
	lbmol/hr
Nitrogen	4739.00
Oxygen	50334.0
Water	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00
Argon	2494.00

Mixer Summary

Equipment name		
number	14	15
Outlet pres. psia	P-out = P-in	P-out = P-in

Heat Exchanger Summary

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Equipment name	number	2	3	4	5
Delta P str 1 psia		1.00000	1.00000	1.00000	1.00000
Delta P str 2 psia		1.00000	1.00000	1.00000	1.00000
Vapor fraction 2 out					1.00000
Min. approach temp. F		100.000	20.0000	10.0000	
Case flag		Design	Design	Design	Design
HTC Btu/ft2-hr-F		20.0000	20.0000	20.0000	50.0000
Calc. duty MMBtu/hr		658.374	922.524	296.599	89.7903
Calc. LMTD F		210.034	42.4447	20.2089	14.7483
Calc. LMTD factor		1.00000	1.00000	1.00000	1.00000
Utility option flag		0	0	0	0
Calc area ft2		156730.	0.108674E+07	733833.	121764.
	H =	50	50	50	100
	A =	62692	434696	293533	60882

Heat Exchanger Summary

Equipment name	number	7	16	18	19
Delta P str 1 psia		1.00000	1.00000	1.00000	0.000000E+00
Delta P str 2 psia		2.00000	1.00000	1.00000	0.000000E+00
T str 2 out R		900.000			
Min. approach temp. F			10.0000	10.0000	
Spec. duty MMBtu/hr					1.00000
Case flag		Design	Design	Design	Design
HTC Btu/ft2-hr-F		50.0000	20.0000	50.0000	
Calc. duty MMBtu/hr		225.172	583.263	820.295	1.00000
Calc. LMTD F		357.923	36.4803	68.2192	
Calc. LMTD factor		1.00000	1.00000	1.00000	
Utility option flag		0	0	0	0
Calc area ft2		12582.1	799421.	240488.	
	H =	100	50	100	
	A =	6291	319768	103056	

Heat Exchanger Summary

Equipment name	number	21	23
Delta P str 1 psia		0.000000E+00	1.00000
Delta P str 2 psia		0.000000E+00	1.00000
Str 1 out subcooled F			0.500000
Case flag		Design	Design
HTC Btu/ft2-hr-F		1400.00	30.0000
Calc. duty MMBtu/hr		158.822	263.377
Calc. LMTD F		14.2689	64.6889
Calc. LMTD factor		1.00000	1.00000
Utility option flag		0	0
Calc area ft2		7950.46	135714.
	H =	70	
	A =	58163	

Pump Summary

Equipment name	6	17	22
number			
Output pres. psia	18.0000		150.000
P increase psia		50.0000	
Pump efficiency	0.850000	0.000000E+00	0.850000
Work required			
Kw	3.18973	40.7976	202.372

Compressor Summary

Equipment name	1
number	
Mode	0
	P-out/ eff.
Pout or ratio psia	450.000
Comp. or Exp. type	Adiabatic
Efficiency	0.850000
Work	
Actual Kw	653521.
Theor. Kw	555493.
Cp/Cv	1.40499

Expander Summary

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Equipment name	9	10	11	20
number	0	0	0	0
Mode	P-out/ eff.	P-out/ eff.	P-out/ eff.	P-out/ eff.
Pout or ratio psia	50.0000	49.0000	48.0000	18.0000
Comp. or Exp. type	Adiabatic	Adiabatic	Adiabatic	Adiabatic
Efficiency	0.850000	0.900000	0.900000	0.900000
Work				
Actual Kw	-3943.17	-72988.6	-73156.0	-9989.18
Theor. Kw	-4639.03	-81098.4	-81284.4	-11099.1
Cp/Cv	1.73225	1.58988	1.44313	1.39945

STREAM PROPERTIES

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Stream No.	1	2	3	4
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	1	2	12	12
To Eqp #	7	18	3	11
lbmol/hr	547845.	547845.	410884.	136961.
Temp R	1123.81	900.883	625.528	625.528
Pres psia	450.000	448.000	446.000	446.000
Enth MMBtu/hr	7104.61	6221.07	3853.05	1284.35
Cp Vap Btu/lb-R	0.260591	0.256487	0.258422	0.258422
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.153468E+08	0.153468E+08	0.115101E+08	0.383670E+07
Std Vap ft3/hr	0.207896E+09	0.207896E+09	0.155922E+09	0.519739E+08
Actual ft3/hr	0.148423E+08	0.119402E+08	0.618545E+07	0.206182E+07
lb/ft3	1.03399	1.28530	1.86084	1.86084
Cp/Cv	1.38997	1.40998	1.44313	1.44313
Compress. factor	1.01103	1.01010	1.00032	1.00032
Th cond Btu/hr-ft-F	0.270334E-01	0.227947E-01	0.176018E-01	0.176018E-01
Visc cp	0.305762E-01	0.263026E-01	0.203729E-01	0.203729E-01

Stream No.	5	6	7	8
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	11	3	13	13
To Eqp #	14	13	4	10
lbmol/hr	136961.	410884.	119693.	291191.
Temp R	358.038	330.212	330.212	330.212
Pres psia	48.0000	445.000	445.000	445.000
Enth MMBtu/hr	1034.57	2930.52	853.679	2076.84
Cp Vap Btu/lb-R	0.254652	0.303083	0.303092	0.303071
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.383670E+07	0.115101E+08	0.335296E+07	0.815713E+07
Std Vap ft3/hr	0.519739E+08	0.155922E+09	0.454209E+08	0.110501E+09
Actual ft3/hr	0.108610E+08	0.292424E+07	851849.	0.207239E+07
lb/ft3	0.353256	3.93610	3.93610	3.93610
Cp/Cv	1.40867	1.58994	1.58999	1.58988
Compress. factor	0.990791	0.893842	0.893842	0.893842
Th cond Btu/hr-ft-F	0.103080E-01	0.159966E-01	0.159966E-01	0.159966E-01
Visc cp	0.128079E-01	0.129819E-01	0.129819E-01	0.129819E-01

STREAM PROPERTIES

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Stream No.	9	10	11	12
Name				
Phase	Vapor	Liquid	Mixed	Vapor
From Eqp #	10	4	9	5
To Eqp #	15	9	21	15
lbmol/hr	291191.	119693.	119693.	119693.
Temp R	184.002	206.943	161.438	229.280
Pres psia	49.0000	444.000	50.0000	49.0000
Enth MMBtu/hr	1827.64	557.080	543.617	792.229
Cp Vap Btu/lb-R	0.275532		0.286036	0.265413
Cp Liq Btu/lb-R		0.777992	0.501762	
Mol Fraction Vapor	1.00000	0.000000E+00	0.296638	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Liquid only - -				
lb/hr		0.335296E+07	0.235835E+07	
Std Liq bbl/hr		11848.5	8333.78	
Sp Gr		0.807463	0.807463	
Actual bbl/hr		16496.6	9024.52	
lb/bbl		203.236	261.306	
Sf tens dyne/cm		1.42349	6.18214	
Th cond Btu/hr-ft-F		0.407848E-01	0.660633E-01	
Visc cp		0.587773E-01	0.112303	
- - Vapor only - -				
lb/hr	0.815713E+07		994616.	0.335296E+07
Std Vap ft3/hr	0.110501E+09		0.134736E+08	0.454209E+08
Actual ft3/hr	0.109196E+08		0.110479E+07	0.578443E+07
lb/ft3	0.747015		0.900274	0.579652
Cp/Cv	1.41858		1.41945	1.41553
Compress. factor	0.930686		0.898152	0.962548
Th cond Btu/hr-ft-F	0.558760E-02		0.491696E-02	0.688577E-02
Visc cp	0.713571E-02		0.631183E-02	0.874238E-02

Stream No.	13	14	15	16
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	15	4	14	3
To Eqp #	4	14	3	1
lbmol/hr	410884.	410884.	547845.	547845.
Temp R	196.943	294.473	310.212	548.043
Pres psia	49.0000	48.0000	48.0000	47.0000
Enth MMBtu/hr	2619.67	2916.27	3950.79	4873.31
Cp Vap Btu/lb-R	0.271745	0.258311	0.257221	0.250148
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.115101E+08	0.115101E+08	0.153468E+08	0.153468E+08
Std Vap ft3/hr	0.155922E+09	0.155922E+09	0.207896E+09	0.207896E+09
Actual ft3/hr	0.167040E+08	0.265738E+08	0.374260E+08	0.684664E+08
lb/ft3	0.689063	0.433137	0.410057	0.224151
Cp/Cv	1.41769	1.41090	1.41021	1.40499
Compress. factor	0.942665	0.982497	0.985141	0.998856
Th cond Btu/hr-ft-F	0.596478E-02	0.866164E-02	0.907639E-02	0.148686E-01
Visc cp	0.760308E-02	0.108232E-01	0.113282E-01	0.180417E-01

STREAM PROPERTIES

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Stream No. Name	17	18	19	20
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	Feed	16	8	5
To Eqp #	16	5	19	8
lbmol/hr	267010.	267010.	209443.	267010.
Temp R	530.000	234.024	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.09	1272.55	1653.30
Cp Vap Btu/lb-R	0.245325	0.282604	0.276390	0.323243
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.9594	28.9594	28.1194	28.9594
- - Vapor only - -				
lb/hr	0.773243E+07	0.773243E+07	0.588941E+07	0.773243E+07
Std Vap ft3/hr	0.101324E+09	0.101324E+09	0.794790E+08	0.101324E+09
Actual ft3/hr	0.100667E+08	0.397596E+07	0.921004E+07	0.300095E+07
lb/ft3	0.768123	1.94479	0.639456	2.57666
Cp/Cv	1.42048	1.50973	1.39919	1.60612
Compress. factor	0.994430	0.883571	0.922840	0.794717
Th cond Btu/hr-ft-F	0.155731E-01	0.196982E-01	0.472025E-02	0.577826E-02
Visc cp	0.181834E-01	0.948756E-02	0.603960E-02	0.820662E-02

Stream No. Name	21	22	23	24
Phase	Vapor	Vapor	Vapor	Liquid
From Eqp #	8	16	7	Feed
To Eqp #	21	2	2	17
lbmol/hr	57567.0	209443.	547845.	7333.32
Temp R	176.960	520.000	1067.35	530.000
Pres psia	35.0000	17.0000	449.000	14.7000
Enth MMBtu/hr	355.092	1822.70	6879.44	-4.35064
Cp Vap Btu/lb-R	0.226897	0.248571	0.259223	
Cp Liq Btu/lb-R				0.420476
Mol Fraction Vapor	1.00000	1.00000	1.00000	0.000000E+00
Average Mol Wt	32.0152	28.1194	28.0130	98.1820
- - Liquid only - -				
lb/hr				720000.
Std Liq bbl/hr				2661.89
Sp Gr				0.771791
Actual bbl/hr				2679.27
lb/bbl				268.709
Sf tens dyne/cm				23.3219
Th cond Btu/hr-ft-F				0.645073E-01
Visc cp				0.719906
- - Vapor only - -				
lb/hr	0.184302E+07	0.588941E+07	0.153468E+08	
Std Vap ft3/hr	0.218454E+08	0.794790E+08	0.207896E+09	
Actual ft3/hr	0.293769E+07	0.686981E+08	0.141275E+08	
lb/ft3	0.627372	0.857288E-01	1.08631	
Cp/Cv	1.41844	1.40100	1.39451	
Compress. factor	0.940645	0.999369	1.01098	
Th cond Btu/hr-ft-F	0.477690E-02	0.142360E-01	0.259699E-01	
Visc cp	0.761262E-02	0.173920E-01	0.295301E-01	

STREAM PROPERTIES

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Stream No.	25	26	27	28
Name				
Phase	Liquid	Vapor	Vapor	Mixed
From Eqp #	17	7	19	20
To Eqp #	7	Product	20	16
lbmol/hr	7333.32	7333.32	209443.	209443.
Temp R	530.162	900.000	156.032	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.44
Cp Vap Btu/lb-R		0.567044	0.276151	0.267923
Cp Liq Btu/lb-R	0.420735			0.474584
Mol Fraction Vapor	0.000000E+00	1.00000	1.00000	0.958264
Average Mol Wt	98.1820	98.1820	28.1194	28.1194
- - Liquid only - -				
lb/hr	720000.			247665.
Std Liq bbl/hr	2661.89			852.726
Sp Gr	0.771791			0.828731
Actual bbl/hr	2678.52			862.986
lb/bbl	268.784			286.964
Sf tens dyne/cm	23.3127			8.67860
Th cond Btu/hr-ft-F	0.644954E-01			0.765437E-01
Visc cp	0.719000			0.151211
- - Vapor only - -				
lb/hr		720000.	0.588941E+07	0.564174E+07
Std Vap ft3/hr		0.278284E+07	0.794790E+08	0.761619E+08
Actual ft3/hr		0.104543E+07	0.925360E+07	0.163915E+08
lb/ft3		0.688710	0.636445	0.344186
Cp/Cv		1.04414	1.39945	1.38060
Compress. factor		0.925595	0.923637	0.953006
Th cond Btu/hr-ft-F		0.196464E-01	0.473847E-02	0.436505E-02
Visc cp		0.110629E-01	0.606242E-02	0.551575E-02

STREAM PROPERTIES

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Stream No. Name	29	30	31	32
Phase	Mixed	water	Liquid	Vapor
From Eqp #	18	Liquid	6	2
To Eqp #	Product	Feed	23	Product
		6		
lbmol/hr	55493.9	55493.9	55493.9	209443.
Temp R	679.626	420.000	419.962	967.355
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	432.059	-651.624	-651.613	2481.08
Cp Vap Btu/lb-R	0.496732			0.253505
Cp Liq Btu/lb-R	1.00409	1.00480	1.00480	
Mol Fraction Vapor	0.852870	0.000000E+00	0.000000E+00	1.00000
Average Mol Wt	18.0200	18.0200	18.0200	28.1194
- - Liquid only - -				
lb/hr	147130.	0.100000E+07	0.100000E+07	
Std Liq bbl/hr	420.149	2855.62	2855.62	
Sp Gr	0.999212	0.999212	0.999212	
Actual bbl/hr	459.997	2697.81	2697.75	
lb/bbl	319.826	370.642	370.650	
Sf tens dyne/cm	57.7694	83.2442	83.2479	
Th cond Btu/hr-ft-F	0.394595	0.277860	0.277829	
Visc cp	0.266432	6.66391	6.66994	
- - Vapor only - -				
lb/hr	852870.			0.588941E+07
Std Vap ft3/hr	0.179604E+08			0.794790E+08
Actual ft3/hr	0.213731E+08			0.135921E+09
lb/ft3	0.399038E-01			0.433296E-01
Cp/Cv	1.42671			1.38717
Compress. factor	0.990811			1.00036
Th cond Btu/hr-ft-F	0.141942E-01			0.238160E-01
Visc cp	0.122529E-01			0.274803E-01

STREAM PROPERTIES

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Stream No.	33	34	35	36
Name				
Phase	Vapor	Mixed	Liquid	Liquid
From Eqp #	18	21	21	22
To Eqp #	23	5	22	Product
lbmol/hr	547845.	119693.	57567.0	57567.0
Temp R	692.183	161.438	174.523	175.319
Pres psia	447.000	50.0000	35.0000	150.000
Enth MMBtu/hr	5400.77	702.439	196.270	196.961
Cp Vap Btu/lb-R	0.256787	0.286038		
Cp Liq Btu/lb-R		0.501737	0.402192	0.394778
Mol Fraction Vapor	1.00000	0.896530	0.100000E-05	0.000000E+00
Average Mol Wt	28.0130	28.0130	32.0152	32.0152
- - Liquid only - -				
lb/hr		346931.	0.184302E+07	0.184302E+07
Std Liq bbl/hr		1225.97	5084.39	5084.39
Sp Gr		0.807463	1.03431	1.03431
Actual bbl/hr		1327.58	4911.61	4922.89
lb/bbl		261.306	375.209	374.349
Sf tens dyne/cm		6.18213	10.4225	10.3174
Th cond Btu/hr-ft-F		0.660632E-01	0.771448E-01	0.768175E-01
Visc cp		0.112303	0.161782	0.160421
- - Vapor only - -				
lb/hr	0.153468E+08	0.300603E+07		
Std Vap ft3/hr	0.207896E+09	0.407212E+08		
Actual ft3/hr	0.914524E+07	0.333902E+07		
lb/ft3	1.67812	0.900274		
Cp/Cv	1.43317	1.41946		
Compress. factor	1.00467	0.898152		
Th cond Btu/hr-ft-F	0.188147E-01	0.491696E-02		
Visc cp	0.218887E-01	0.631183E-02		

STREAM PROPERTIES

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Stream No.	37	38
Name		
Phase	Vapor	Liquid
From Eqp #	23	23
To Eqp #	12	18
lbmol/hr	547845.	55493.9
Temp R	625.528	682.183
Pres psia	446.000	17.0000
Enth MMBtu/hr	5137.40	-388.236
Cp Vap Btu/lb-R	0.258422	
Cp Liq Btu/lb-R		1.00410
Mol Fraction Vapor	1.00000	0.000000E+00
Average Mol Wt	28.0130	18.0200
- - Liquid only - -		
lb/hr		0.100000E+07
Std Liq bbl/hr		2855.62
Sp Gr		0.999212
Actual bbl/hr		3131.29
lb/bbl		319.333
Sf tens dyne/cm		57.4976
Th cond Btu/hr-ft-F		0.394885
Visc cp		0.262520
- - Vapor only - -		
lb/hr	0.153468E+08	
Std Vap ft3/hr	0.207896E+09	
Actual ft3/hr	0.824726E+07	
lb/ft3	1.86084	
Cp/Cv	1.44313	
Compress. factor	1.00032	
Th cond Btu/hr-ft-F	0.176018E-01	
Visc cp	0.203729E-01	

FLOW SUMMARIES

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Stream No.	1	2	3	4
Name				
Temp R	1123.81	900.883	625.528	625.528
Pres psia	450.000	448.000	446.000	446.000
Enth MMBtu/hr	7104.61	6221.07	3853.05	1284.35
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	547845.	547845.	410884.	136961.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	5	6	7	8
Name				
Temp R	358.038	330.212	330.212	330.212
Pres psia	48.0000	445.000	445.000	445.000
Enth MMBtu/hr	1034.57	2930.52	853.679	2076.84
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	136961.	410884.	119693.	291191.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	9	10	11	12
Name				
Temp R	184.002	206.943	161.438	229.280
Pres psia	49.0000	444.000	50.0000	49.0000
Enth MMBtu/hr	1827.64	557.080	543.617	792.229
Vapor mole fraction	1.00000	0.000000E+00	0.296638	1.00000
Total lbmol/hr	291191.	119693.	119693.	119693.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.000000	1.000000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	13	14	15	16
Name				
Temp R	196.943	294.473	310.212	548.043
Pres psia	49.0000	48.0000	48.0000	47.0000
Enth MMBtu/hr	2619.67	2916.27	3950.79	4873.31
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	410884.	410884.	547845.	547845.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

FLOW SUMMARIES

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Stream No.	17	18	19	20
Name				
Temp R	530.000	234.024	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.09	1272.55	1653.30
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	267010.	267010.	209443.	267010.
Component mole fractions				
Nitrogen	0.781204	0.781204	0.973297	0.781204
Oxygen	0.209456	0.209456	0.267030E-01	0.209456
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.934046E-02	0.934046E-02	0.000000E+00	0.934046E-02
Stream No.	21	22	23	24
Name				
Temp R	176.960	520.000	1067.35	530.000
Pres psia	35.0000	17.0000	449.000	14.7000
Enth MMBtu/hr	355.092	1822.70	6879.44	-4.35064
Vapor mole fraction	1.00000	1.00000	1.00000	0.000000E+00
Total lbmol/hr	57567.0	209443.	547845.	7333.32
Component mole fractions				
Nitrogen	0.823215E-01	0.973297	1.00000	0.000000E+00
Oxygen	0.874355	0.267030E-01	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	1.00000
Argon	0.433233E-01	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	25	26	27	28
Name				
Temp R	530.162	900.000	156.032	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.44
Vapor mole fraction	0.000000E+00	1.00000	1.00000	0.958264
Total lbmol/hr	7333.32	7333.32	209443.	209443.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	0.973297	0.973297
Oxygen	0.000000E+00	0.000000E+00	0.267030E-01	0.267030E-01
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	1.00000	1.00000	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	29	30	31	32
Name		water		
Temp R	679.626	420.000	419.962	967.355
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	432.059	-651.624	-651.613	2481.08
Vapor mole fraction	0.852870	0.000000E+00	0.000000E+00	1.00000
Total lbmol/hr	55493.9	55493.9	55493.9	209443.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	0.000000E+00	0.973297
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.267030E-01
Water	1.00000	1.00000	1.00000	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

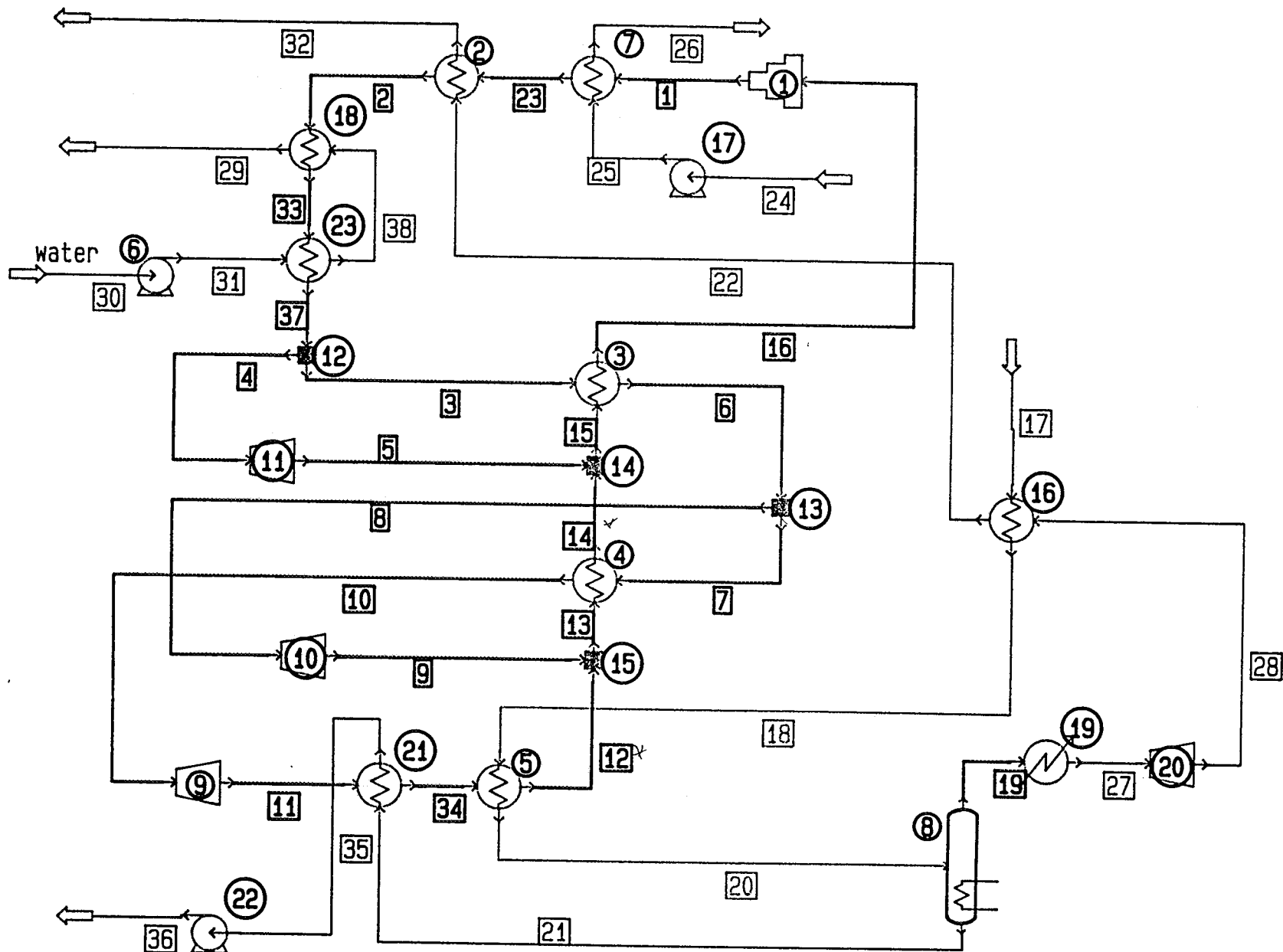
FLOW SUMMARIES

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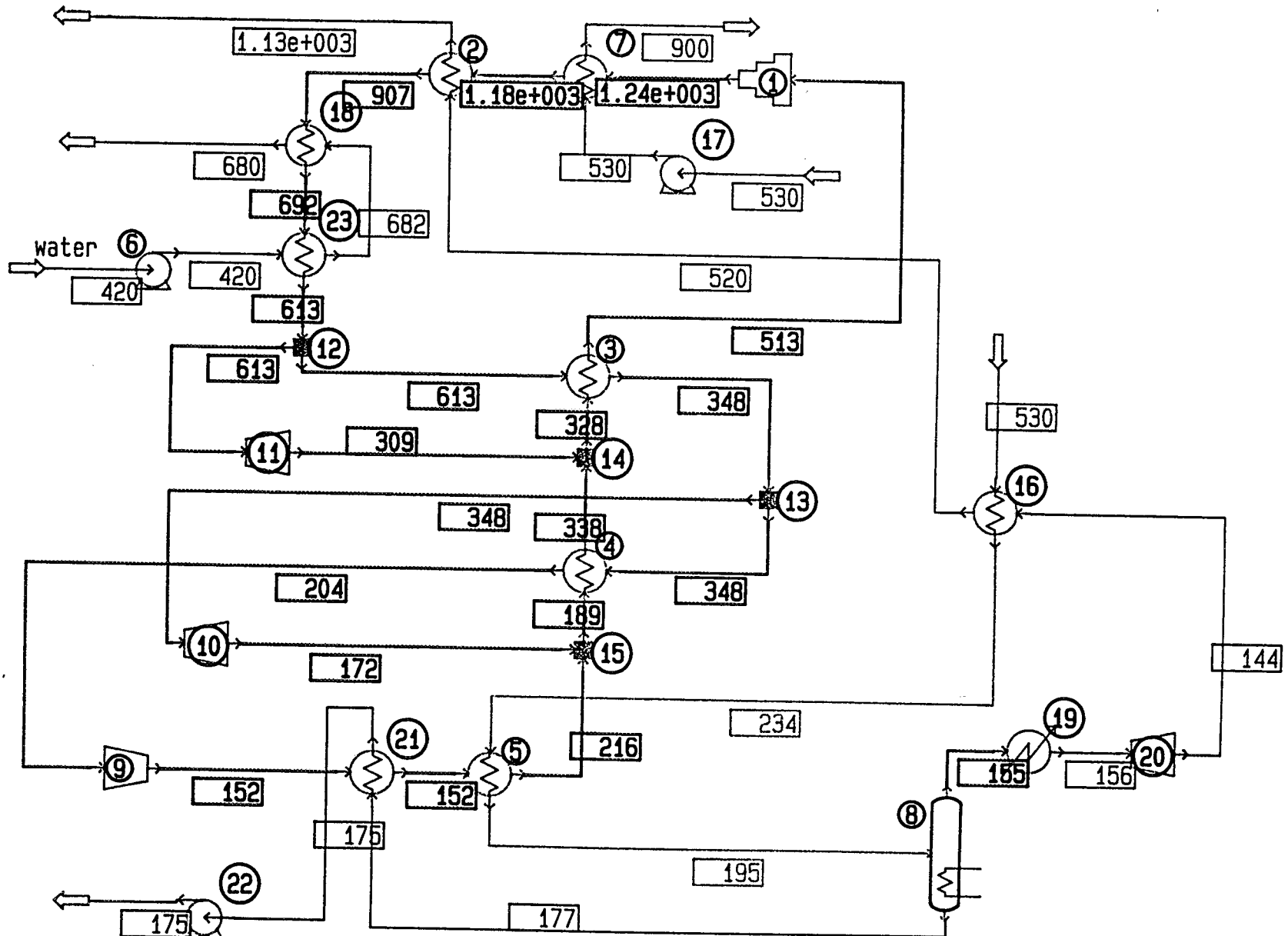
Stream No.	33	34	35	36
Name				
Temp R	692.183	161.438	174.523	175.319
Pres psia	447.000	50.0000	35.0000	150.000
Enth MMBtu/hr	5400.77	702.439	196.270	196.961
Vapor mole fraction	1.00000	0.896530	0.100000E-05	0.000000E+00
Total lbmol/hr	547845.	119693.	57567.0	57567.0
Component mole fractions				
Nitrogen	1.00000	1.000000	0.823215E-01	0.823215E-01
Oxygen	0.000000E+00	0.000000E+00	0.874355	0.874355
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.433233E-01	0.433233E-01
Stream No.	37	38		
Name				
Temp R	625.528	682.183		
Pres psia	446.000	17.0000		
Enth MMBtu/hr	5137.40	-388.236		
Vapor mole fraction	1.00000	0.000000E+00		
Total lbmol/hr	547845.	55493.9		
Component mole fractions				
Nitrogen	1.00000	0.000000E+00		
Oxygen	0.000000E+00	0.000000E+00		
Water	0.000000E+00	1.00000		
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00		
Argon	0.000000E+00	0.000000E+00		

CASE 2

JP-4/Slush Cycle
Recycle Pressure 450 to 26 PSIA
Stream and Equipment Numbers



CASE 2
JP-4/Slush Cycle
Recycle Pressure 450 to 26 PSIA
Stream Temperatures



Filename : LIN500A.TLK

Date: 9-Apr-92 Time: 8:31 am

SINGLE COMPRESSOR AND THREE EXPANDERS

FLOWSHEET SUMMARY

Equipment	Stream Numbers			
1 COMP	16	-1		
2 HTXR	23	22	-2	-32
3 HTXR	3	15	-6	-16
4 HTXR	7	13	-10	-14
5 HTXR	34	18	-12	-20
6 PUMP	30	-31		
7 HTXR	1	25	-23	-26
8 CSEP	20	-19	-21	
9 EXPN	10	-11		
10 EXPN	8	-9		
11 EXPN	4	-5		
12 DIVI	37	-4	-3	
13 DIVI	6	-8	-7	
14 MIXE	14	5	-15	
15 MIXE	12	9	-13	
16 HTXR	28	17	-22	-18
17 PUMP	24	-25		
18 HTXR	38	2	-29	-33
19 HTXR	19	-27		
20 EXPN	27	-28		
21 HTXR	11	21	-34	-35
22 PUMP	35	-36		
23 HTXR	31	33	-38	-37

Stream Connections

Stream	Equipment		Stream	Equipment		Stream	Equipment	
	From	To		From	To		From	To
1	1	7	14	4	14	27	19	20
2	2	18	15	14	3	28	20	16
3	12	3	16	3	1	29	18	
4	12	11	17		16	30		6
5	11	14	18	16	5	31	6	23
6	3	13	19	8	19	32	2	
7	13	4	20	5	8	33	18	23
8	13	10	21	8	21	34	21	5
9	10	15	22	16	2	35	21	22
10	4	9	23	7	2	36	22	
11	9	21	24		17	37	23	12
12	5	15	25	17	7	38	23	18
13	15	4	26	7				

Recycle Sequence

23 12 11 14 3 13 10 15 4 9 21 5 8 19 20 16 1

Recycle Sequence

7 2 18

Cut Streams

33 14 12 18 21

Accelerated Streams

33 14 12 18 21

Dominant Eigenvalue Method, frequency = 4

Recycle calculations have converged

COMPONENTS

46 47 62 39 98

THERMODYNAMICS

K-value model :Peng-Robinson

Enthalpy model :Peng-Robinson

Liquid density :API

Water miscible

Divider Summary

Equipment name	12	13
number		
Mode	0	0
	Ratio	Ratio
Flow rate/ratio	0.350000	0.600000
Flow rate/ratio	0.650000	0.400000

Component Separator Summary

Equipment name	
number	8
P out / del P psia	35.0000
Top temp. mode	2
	Dew point
Top spec. value R	
Bottom temp. mode	2
	Dew point
Bottom spec. value R	
Component split mode	1
Split destination	Bottom
	lbmol/hr
Nitrogen	4739.00
Oxygen	50334.0
Water	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00
Argon	2494.00

Mixer Summary

Equipment name		
number	14	15
Outlet pres. psia	P-out = P-in	P-out = P-in

Heat Exchanger Summary

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Equipment name	number	2	3	4	5
Delta P str 1 psia		1.00000	1.00000	1.00000	1.00000
Delta P str 2 psia		1.00000	1.00000	1.00000	1.00000
Vapor fraction 2 out					1.00000
Min. approach temp. F		50.0000	20.0000	10.0000	
Case flag		Design	Design	Design	Design
HTC Btu/ft2-hr-F		20.0000	20.0000	20.0000	50.0000
Calc. duty MMBtu/hr		896.055	600.902	322.092	89.7903
Calc. LMTD F		164.631	49.7555	12.1863	29.3335
Calc. LMTD factor		1.00000	1.00000	1.00000	1.00000
Utility option flag		0	0	0	0
Calc area ft2		272141.	603855.	0.132153E+07	61220.3
	H=	50	50	50	100
	A=	105855	241542	528512	30810

Heat Exchanger Summary

Equipment name	number	7	16	18	19
Delta P str 1 psia		1.00000	1.00000	1.00000	0.000000E+00
Delta P str 2 psia		2.00000	1.00000	1.00000	0.000000E+00
T str 2 out R		900.000			
Min. approach temp. F			10.0000	10.0000	
Spec. duty MMBtu/hr					1.00000
Case flag		Design	Design	Design	Design
HTC Btu/ft2-hr-F		50.0000	20.0000	50.0000	
Calc. duty MMBtu/hr		225.172	583.335	709.068	1.00000
Calc. LMTD F		477.456	36.4740	69.5434	
Calc. LMTD factor		1.00000	1.00000	1.00000	
Utility option flag		0	0	0	0
Calc area ft2		9432.15	799658.	203921.	
	H=	100	50	100	
	A=	4716	319853	87395	

Heat Exchanger Summary

Equipment name	number	21	23
Delta P str 1 psia		0.000000E+00	1.00000
Delta P str 2 psia		0.000000E+00	1.00000
Str 1 out subcooled F			0.500000
Case flag		Design	Design
HTC Btu/ft2-hr-F		1400.00	30.0000
Calc. duty MMBtu/hr		158.822	263.377
Calc. LMTD F		24.2071	61.8305
Calc. LMTD factor		1.00000	1.00000
Utility option flag		0	0
Calc area ft2		4686.39	141988.
	H=		70
	A=		60852

Pump Summary

Equipment name			
number	6	17	22
Output pres. psia	18.0000		150.000
P increase psia		50.0000	
Pump efficiency	0.850000	0.000000E+00	0.850000
Work required			
Kw	3.18973	40.7976	202.372

Compressor Summary

Equipment name	
number	1
Mode	0
	P-out/ eff.
Pout or ratio psia	450.000
Comp. or Exp. type	Adiabatic
Efficiency	0.850000
Work	
Actual Kw	698572.
Theor. Kw	593789.
Cp/Cv	1.40240

Expander Summary

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Equipment name	9	10	11	20
number	0	0	0	0
Mode	P-out/ eff.	P-out/ eff.	P-out/ eff.	P-out/ eff.
Pout or ratio psia	30.0000	29.0000	28.0000	18.0000
Comp. or Exp. type	Adiabatic	Adiabatic	Adiabatic	Adiabatic
Efficiency	0.800000	0.900000	0.900000	0.900000
Work				
Actual Kw	-4476.74	-56052.0	-97660.2	-10010.2
Theor. Kw	-5595.97	-62280.0	-108511.	-11122.5
Cp/Cv	1.77480	1.56427	1.44496	1.39954

STREAM PROPERTIES

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Stream No.	1	2	3	4
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	1	2	12	12
To Eqp #	7	18	3	11
lbmol/hr	460359.	460359.	299234.	161126.
Temp R	1241.72	906.828	612.998	612.998
Pres psia	450.000	448.000	446.000	446.000
Enth MMBtu/hr	6368.61	5247.39	2778.71	1496.23
Cp Vap Btu/lb-R	0.263622	0.256555	0.258797	0.258801
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.128960E+08	0.128960E+08	0.838243E+07	0.451362E+07
Std Vap ft3/hr	0.174697E+09	0.174697E+09	0.113553E+09	0.611438E+08
Actual ft3/hr	0.137781E+08	0.101003E+08	0.440974E+07	0.237447E+07
lb/ft3	0.935982	1.27680	1.90089	1.90089
Cp/Cv	1.37975	1.40942	1.44493	1.44496
Compress. factor	1.01083	1.01016	0.999259	0.999259
Th cond Btu/hr-ft-F	0.292274E-01	0.229088E-01	0.173820E-01	0.173820E-01
Visc cp	0.326907E-01	0.264219E-01	0.200816E-01	0.200816E-01

Stream No.	5	6	7	8
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	11	3	13	13
To Eqp #	14	13	4	10
lbmol/hr	161126.	299234.	119693.	179540.
Temp R	309.304	347.607	347.607	347.607
Pres psia	28.0000	445.000	445.000	445.000
Enth MMBtu/hr	1162.79	2177.81	871.124	1306.69
Cp Vap Btu/lb-R	0.255029	0.294925	0.294941	0.294941
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.451362E+07	0.838243E+07	0.335297E+07	0.502946E+07
Std Vap ft3/hr	0.611438E+08	0.113553E+09	0.454211E+08	0.681316E+08
Actual ft3/hr	0.189309E+08	0.228754E+07	915015.	0.137252E+07
lb/ft3	0.238426	3.66439	3.66439	3.66439
Cp/Cv	1.40232	1.56419	1.56427	1.56427
Compress. factor	0.991241	0.912074	0.912074	0.912074
Th cond Btu/hr-ft-F	0.905259E-02	0.155244E-01	0.155244E-01	0.155244E-01
Visc cp	0.112993E-01	0.134303E-01	0.134303E-01	0.134303E-01

STREAM PROPERTIES

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Stream No.	9	10	11	12
Name				
Phase	Vapor	Liquid	Mixed	Vapor
From Eqp #	10	4	9	5
To Eqp #	15	9	21	15
lbmol/hr	179540.	119693.	119693.	119693.
Temp R	171.630	203.711	151.514	215.393
Pres psia	29.0000	444.000	30.0000	29.0000
Enth MMBtu/hr	1115.31	549.032	533.748	782.360
Cp Vap Btu/lb-R	0.269134		0.275528	0.262129
Cp Liq Btu/lb-R		0.725956	0.499232	
Mol Fraction Vapor	1.00000	0.000000E+00	0.307223	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Liquid only - -				
lb/hr		0.335297E+07	0.232286E+07	
Std Liq bbl/hr		11848.5	8208.40	
Sp Gr		0.807463	0.807463	
Actual bbl/hr		16060.9	8568.76	
lb/bbl		208.750	271.064	
Sf tens dyne/cm		1.71234	7.36580	
Th cond Btu/hr-ft-F		0.430904E-01	0.711611E-01	
Visc cp		0.630730E-01	0.128163	
- - Vapor only - -				
lb/hr	0.502946E+07		0.103011E+07	0.335297E+07
Std Vap ft3/hr	0.681316E+08		0.139544E+08	0.454211E+08
Actual ft3/hr	0.108497E+08		0.185345E+07	0.928918E+07
lb/ft3	0.463556		0.555779	0.360955
Cp/Cv	1.39830		1.39243	1.40234
Compress. factor	0.951619		0.930094	0.973810
Th cond Btu/hr-ft-F	0.522198E-02		0.461647E-02	0.649386E-02
Visc cp	0.660725E-02		0.584999E-02	0.813046E-02

Stream No.	13	14	15	16
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	15	4	14	3
To Eqp #	4	14	3	1
lbmol/hr	299234.	299234.	460359.	460359.
Temp R	189.040	337.607	327.607	512.842
Pres psia	29.0000	28.0000	28.0000	27.0000
Enth MMBtu/hr	1897.71	2219.80	3382.60	3983.50
Cp Vap Btu/lb-R	0.265775	0.253788	0.254212	0.249806
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.838243E+07	0.838243E+07	0.128960E+08	0.128960E+08
Std Vap ft3/hr	0.113553E+09	0.113553E+09	0.174697E+09	0.174697E+09
Actual ft3/hr	0.201478E+08	0.384618E+08	0.573745E+08	0.937253E+08
lb/ft3	0.416047	0.217942	0.224770	0.137594
Cp/Cv	1.40090	1.40234	1.40240	1.40243
Compress. factor	0.962634	0.993497	0.992721	0.998941
Th cond Btu/hr-ft-F	0.573507E-02	0.978686E-02	0.952912E-02	0.140568E-01
Visc cp	0.725242E-02	0.121854E-01	0.118755E-01	0.171366E-01

STREAM PROPERTIES

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Stream No. Name	17	18	19	20
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	Feed	16	8	5
To Eqp #	16	5	19	8
lbmol/hr	267010.	267010.	209443.	267010.
Temp R	530.000	234.001	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.01	1272.55	1653.30
Cp Vap Btu/lb-R	0.245325	0.282604	0.276412	0.323243
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.9594	28.9594	28.1194	28.9594
- - Vapor only - -				
lb/hr	0.773243E+07	0.773243E+07	0.588941E+07	0.773243E+07
Std Vap ft3/hr	0.101324E+09	0.101324E+09	0.794790E+08	0.101324E+09
Actual ft3/hr	0.100667E+08	0.397541E+07	0.921004E+07	0.300095E+07
lb/ft3	0.768123	1.94506	0.639456	2.57666
Cp/Cv	1.42048	1.50969	1.39930	1.60612
Compress. factor	0.994430	0.883536	0.922840	0.794717
Th cond Btu/hr-ft-F	0.155731E-01	0.197015E-01	0.472026E-02	0.577826E-02
Visc cp	0.181834E-01	0.948679E-02	0.603960E-02	0.820662E-02

Stream No. Name	21	22	23	24
Phase	Vapor	Vapor	Vapor	Liquid
From Eqp #	8	16	7	Feed
To Eqp #	21	2	2	17
lbmol/hr	57567.0	209443.	460359.	7333.32
Temp R	176.960	520.000	1175.27	530.000
Pres psia	35.0000	17.0000	449.000	14.7000
Enth MMBtu/hr	355.092	1822.70	6143.44	-4.35064
Cp Vap Btu/lb-R	0.226897	0.248571	0.261875	
Cp Liq Btu/lb-R				0.420476
Mol Fraction Vapor	1.00000	1.00000	1.00000	0.000000E+00
Average Mol Wt	32.0152	28.1194	28.0130	98.1820
- - Liquid only - -				
lb/hr				720000.
Std Liq bbl/hr				2661.89
Sp Gr				0.771791
Actual bbl/hr				2679.27
lb/bbl				268.709
Sf tens dyne/cm				23.3219
Th cond Btu/hr-ft-F				0.645073E-01
Visc cp				0.719906
- - Vapor only - -				
lb/hr	0.184302E+07	0.588941E+07	0.128960E+08	
Std Vap ft3/hr	0.218454E+08	0.794790E+08	0.174697E+09	
Actual ft3/hr	0.293769E+07	0.686981E+08	0.130712E+08	
lb/ft3	0.627372	0.857288E-01	0.986600	
Cp/Cv	1.41844	1.40100	1.38553	
Compress. factor	0.940645	0.999369	1.01095	
Th cond Btu/hr-ft-F	0.477690E-02	0.142360E-01	0.279951E-01	
Visc cp	0.761262E-02	0.173920E-01	0.315095E-01	

STREAM PROPERTIES

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Stream No.	25	26	27	28
Name				
Phase	Liquid	Vapor	Vapor	Mixed
From Eqp #	17	7	19	20
To Eqp #	7	Product	20	16
lbmol/hr	7333.32	7333.32	209443.	209443.
Temp R	530.162	900.000	156.026	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.37
Cp Vap Btu/lb-R		0.567044	0.276173	0.267927
Cp Liq Btu/lb-R	0.420735			0.474549
Mol Fraction Vapor	0.000000E+00	1.00000	1.00000	0.958409
Average Mol Wt	98.1820	98.1820	28.1194	28.1194
- - Liquid only - -				
lb/hr	720000.			246806.
Std Liq bbl/hr	2661.89			849.764
Sp Gr	0.771791			0.828737
Actual bbl/hr	2678.52			859.988
lb/bbl	268.784			286.966
Sf tens dyne/cm	23.3127			8.67867
Th cond Btu/hr-ft-F	0.644954E-01			0.765438E-01
Visc cp	0.719000			0.151213
- - Vapor only - -				
lb/hr		720000.	0.588941E+07	0.564260E+07
Std Vap ft3/hr		0.278284E+07	0.794790E+08	0.761734E+08
Actual ft3/hr		0.104543E+07	0.925322E+07	0.163940E+08
lb/ft3		0.688710	0.636472	0.344186
Cp/Cv		1.04414	1.39954	1.38063
Compress. factor		0.925595	0.923630	0.953006
Th cond Btu/hr-ft-F		0.196464E-01	0.473831E-02	0.436506E-02
Visc cp		0.110629E-01	0.606222E-02	0.551576E-02

STREAM PROPERTIES

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Stream No.	29	30	31	32
Name		water		
Phase	Mixed	Liquid	Liquid	Vapor
From Eqp #	18	Feed	6	2
To Eqp #	Product	6	23	Product
lbmol/hr	55493.9	55493.9	55493.9	209443.
Temp R	679.626	420.000	419.962	1125.27
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	320.832	-651.624	-651.613	2718.76
Cp Vap Btu/lb-R	0.496755			0.257808
Cp Liq Btu/lb-R	1.00410	1.00480	1.00480	
Mol Fraction Vapor	0.737587	0.000000E+00	0.000000E+00	1.00000
Average Mol Wt	18.0200	18.0200	18.0200	28.1194
- - Liquid only - -				
lb/hr	262413.	0.100000E+07	0.100000E+07	
Std Liq bbl/hr	749.352	2855.62	2855.62	
Sp Gr	0.999212	0.999212	0.999212	
Actual bbl/hr	820.424	2697.81	2697.75	
lb/bbl	319.826	370.642	370.650	
Sf tens dyne/cm	57.7694	83.2442	83.2479	
Th cond Btu/hr-ft-F	0.394595	0.277860	0.277829	
Visc cp	0.266432	6.66391	6.66994	
- - Vapor only - -				
lb/hr	737587.			0.588941E+07
Std Vap ft3/hr	0.155327E+08			0.794790E+08
Actual ft3/hr	0.184841E+08			0.158112E+09
lb/ft3	0.399038E-01			0.372483E-01
Cp/Cv	1.42678			1.37807
Compress. factor	0.990811			1.00038
Th cond Btu/hr-ft-F	0.141942E-01			0.269139E-01
Visc cp	0.122529E-01			0.305185E-01

STREAM PROPERTIES

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Stream No. Name	33	34	35	36
Phase	Vapor	Mixed	Liquid	Liquid
From Eqp #	18	21	21	22
To Eqp #	23	5	22	Product
lbmol/hr	460359.	119693.	57567.0	57567.0
Temp R	692.183	151.514	174.523	175.319
Pres psia	447.000	30.0000	35.0000	150.000
Enth MMBtu/hr	4538.32	692.569	196.270	196.961
Cp Vap Btu/lb-R	0.256793	0.275525		
Cp Liq Btu/lb-R		0.499240	0.402192	0.394778
Mol Fraction Vapor	1.00000	0.882796	0.100000E-05	0.000000E+00
Average Mol Wt	28.0130	28.0130	32.0152	32.0152
- - Liquid only - -				
lb/hr		392981.	0.184302E+07	0.184302E+07
Std Liq bbl/hr		1388.69	5084.39	5084.39
Sp Gr		0.807463	1.03431	1.03431
Actual bbl/hr		1449.66	4911.61	4922.89
lb/bbl		271.064	375.209	374.349
Sf tens dyne/cm		7.36580	10.4225	10.3174
Th cond Btu/hr-ft-F		0.711611E-01	0.771448E-01	0.768175E-01
Visc cp		0.128163	0.161782	0.160421
- - Vapor only - -				
lb/hr	0.128960E+08	0.295999E+07		
Std Vap ft3/hr	0.174697E+09	0.400976E+08		
Actual ft3/hr	0.768483E+07	0.532584E+07		
lb/ft3	1.67812	0.555779		
Cp/Cv	1.43321	1.39242		
Compress. factor	1.00467	0.930094		
Th cond Btu/hr-ft-F	0.188147E-01	0.461647E-02		
Visc cp	0.218887E-01	0.584999E-02		

STREAM PROPERTIES

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Stream No.	37	38
Name		
Phase	Vapor	Liquid
From Eqp #	23	23
To Eqp #	12	18
lbmol/hr	460359.	55493.9
Temp R	612.998	682.183
Pres psia	446.000	17.0000
Enth MMBtu/hr	4274.94	-388.236
Cp Vap Btu/lb-R	0.258818	
Cp Liq Btu/lb-R		1.00410
Mol Fraction Vapor	1.00000	0.000000E+00
Average Mol Wt	28.0130	18.0200
- - Liquid only - -		
lb/hr		0.100000E+07
Std Liq bbl/hr		2855.62
Sp Gr		0.999212
Actual bbl/hr		3131.29
lb/bbl		319.333
Sf tens dyne/cm		57.4976
Th cond Btu/hr-ft-F		0.394885
Visc cp		0.262520
- - Vapor only - -		
lb/hr	0.128960E+08	
Std Vap ft3/hr	0.174697E+09	
Actual ft3/hr	0.678421E+07	
lb/ft3	1.90089	
Cp/Cv	1.44505	
Compress. factor	0.999259	
Th cond Btu/hr-ft-F	0.173820E-01	
Visc cp	0.200816E-01	

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Stream No. Name	1	2	3	4
Temp R	1241.72	906.828	612.998	612.998
Pres psia	450.000	448.000	446.000	446.000
Enth MMBtu/hr	6368.61	5247.39	2778.71	1496.23
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	460359.	460359.	299234.	161126.
Flowrates in lbmol/hr				
Nitrogen	460359.	460359.	299234.	161126.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	5	6	7	8
Temp R	309.304	347.607	347.607	347.607
Pres psia	28.0000	445.000	445.000	445.000
Enth MMBtu/hr	1162.79	2177.81	871.124	1306.69
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	161126.	299234.	119693.	179540.
Flowrates in lbmol/hr				
Nitrogen	161126.	299234.	119693.	179540.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	9	10	11	12
Temp R	171.630	203.711	151.514	215.393
Pres psia	29.0000	444.000	30.0000	29.0000
Enth MMBtu/hr	1115.31	549.032	533.748	782.360
Vapor mole fraction	1.00000	0.000000E+00	0.307223	1.00000
Total lbmol/hr	179540.	119693.	119693.	119693.
Flowrates in lbmol/hr				
Nitrogen	179540.	119693.	119693.	119693.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	13	14	15	16
Temp R	189.040	337.607	327.607	512.842
Pres psia	29.0000	28.0000	28.0000	27.0000
Enth MMBtu/hr	1897.71	2219.80	3382.60	3983.50
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	299234.	299234.	460359.	460359.
Flowrates in lbmol/hr				
Nitrogen	299234.	299234.	460359.	460359.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

FLOW SUMMARIES

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Stream No.	17	18	19	20
Name				
Temp R	530.000	234.001	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.01	1272.55	1653.30
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	267010.	267010.	209443.	267010.
Flowrates in lbmol/hr				
Nitrogen	208589.	208589.	203850.	208589.
Oxygen	55926.7	55926.7	5592.75	55926.7
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	2493.99	2493.99	0.000000E+00	2493.99
Stream No.	21	22	23	24
Name				
Temp R	176.960	520.000	1175.27	530.000
Pres psia	35.0000	17.0000	449.000	14.7000
Enth MMBtu/hr	355.092	1822.70	6143.44	-4.35064
Vapor mole fraction	1.00000	1.00000	1.00000	0.000000E+00
Total lbmol/hr	57567.0	209443.	460359.	7333.32
Flowrates in lbmol/hr				
Nitrogen	4739.00	203850.	460359.	0.000000E+00
Oxygen	50334.0	5592.75	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	7333.32
Argon	2493.99	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	25	26	27	28
Name				
Temp R	530.162	900.000	156.026	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.37
Vapor mole fraction	0.000000E+00	1.00000	1.00000	0.958409
Total lbmol/hr	7333.32	7333.32	209443.	209443.
Flowrates in lbmol/hr				
Nitrogen	0.000000E+00	0.000000E+00	203850.	203850.
Oxygen	0.000000E+00	0.000000E+00	5592.75	5592.75
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	7333.32	7333.32	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	29	30	31	32
Name		water		
Temp R	679.626	420.000	419.962	1125.27
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	320.832	-651.624	-651.613	2718.76
Vapor mole fraction	0.737587	0.000000E+00	0.000000E+00	1.00000
Total lbmol/hr	55493.9	55493.9	55493.9	209443.
Flowrates in lbmol/hr				
Nitrogen	0.000000E+00	0.000000E+00	0.000000E+00	203850.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	5592.75
Water	55493.9	55493.9	55493.9	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

FLOW SUMMARIES

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Stream No. Name	33	34	35	36
Temp R	692.183	151.514	174.523	175.319
Pres psia	447.000	30.0000	35.0000	150.000
Enth MMBtu/hr	4538.32	692.569	196.270	196.961
Vapor mole fraction	1.00000	0.882796	0.100000E-05	0.000000E+00
Total lbmol/hr	460359.	119693.	57567.0	57567.0
Flowrates in lbmol/hr				
Nitrogen	460359.	119693.	4739.00	4739.00
Oxygen	0.000000E+00	0.000000E+00	50334.0	50334.0
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	2493.99	2493.99

Stream No. Name	37	38
Temp R	612.998	682.183
Pres psia	446.000	17.0000
Enth MMBtu/hr	4274.94	-388.236
Vapor mole fraction	1.00000	0.000000E+00
Total lbmol/hr	460359.	55493.9
Flowrates in lbmol/hr		
Nitrogen	460359.	0.000000E+00
Oxygen	0.000000E+00	0.000000E+00
Water	0.000000E+00	55493.9
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00

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Stream No.	1	2	3	4
Name				
Temp R	1241.72	906.828	612.998	612.998
Pres psia	450.000	448.000	446.000	446.000
Enth MMBtu/hr	6368.61	5247.39	2778.71	1496.23
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	460359.	460359.	299234.	161126.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	5	6	7	8
Name				
Temp R	309.304	347.607	347.607	347.607
Pres psia	28.0000	445.000	445.000	445.000
Enth MMBtu/hr	1162.79	2177.81	871.124	1306.69
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	161126.	299234.	119693.	179540.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	9	10	11	12
Name				
Temp R	171.630	203.711	151.514	215.393
Pres psia	29.0000	444.000	30.0000	29.0000
Enth MMBtu/hr	1115.31	549.032	533.748	782.360
Vapor mole fraction	1.00000	0.000000E+00	0.307223	1.00000
Total lbmol/hr	179540.	119693.	119693.	119693.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	13	14	15	16
Name				
Temp R	189.040	337.607	327.607	512.842
Pres psia	29.0000	28.0000	28.0000	27.0000
Enth MMBtu/hr	1897.71	2219.80	3382.60	3983.50
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	299234.	299234.	460359.	460359.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

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Stream No.	17	18	19	20
Name				
Temp R	530.000	234.001	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.01	1272.55	1653.30
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	267010.	267010.	209443.	267010.
Component mole fractions				
Nitrogen	0.781204	0.781204	0.973297	0.781204
Oxygen	0.209456	0.209456	0.267030E-01	0.209456
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.934046E-02	0.934046E-02	0.000000E+00	0.934046E-02
Stream No.	21	22	23	24
Name				
Temp R	176.960	520.000	1175.27	530.000
Pres psia	35.0000	17.0000	449.000	14.7000
Enth MMBtu/hr	355.092	1822.70	6143.44	-4.35064
Vapor mole fraction	1.00000	1.00000	1.00000	0.000000E+00
Total lbmol/hr	57567.0	209443.	460359.	7333.32
Component mole fractions				
Nitrogen	0.823215E-01	0.973297	1.00000	0.000000E+00
Oxygen	0.874355	0.267030E-01	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	1.00000
Argon	0.433233E-01	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	25	26	27	28
Name				
Temp R	530.162	900.000	156.026	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.37
Vapor mole fraction	0.000000E+00	1.00000	1.00000	0.958409
Total lbmol/hr	7333.32	7333.32	209443.	209443.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	0.973297	0.973297
Oxygen	0.000000E+00	0.000000E+00	0.267030E-01	0.267030E-01
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	1.00000	1.00000	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	29	30	31	32
Name		water		
Temp R	679.626	420.000	419.962	1125.27
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	320.832	-651.624	-651.613	2718.76
Vapor mole fraction	0.737587	0.000000E+00	0.000000E+00	1.00000
Total lbmol/hr	55493.9	55493.9	55493.9	209443.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	0.000000E+00	0.973297
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.267030E-01
Water	1.00000	1.00000	1.00000	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

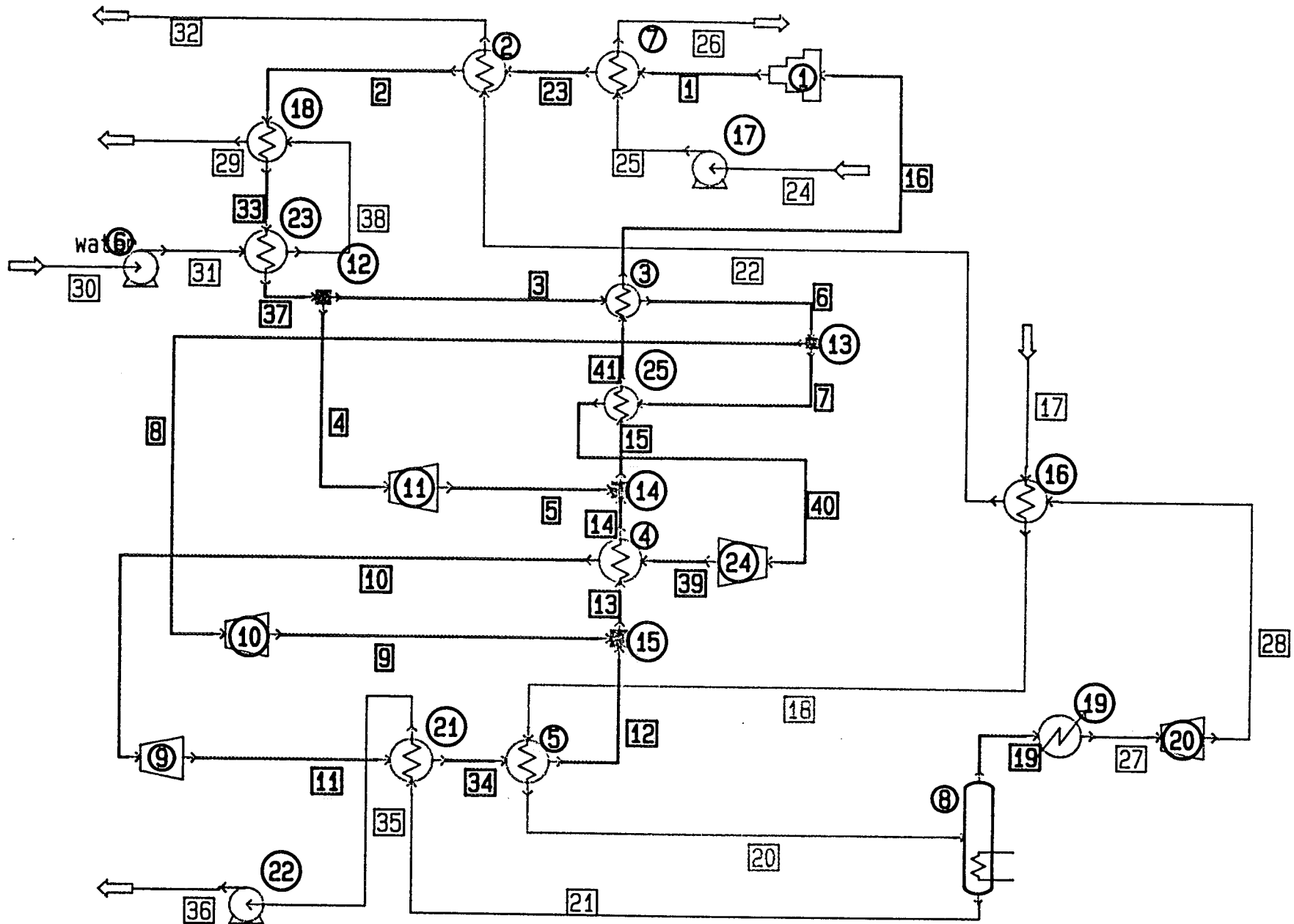
FLOW SUMMARIES

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Stream No.	33	34	35	36
Name				
Temp R	692.183	151.514	174.523	175.319
Pres psia	447.000	30.0000	35.0000	150.000
Enth MMBtu/hr	4538.32	692.569	196.270	196.961
Vapor mole fraction	1.00000	0.882796	0.100000E-05	0.000000E+00
Total lbmol/hr	460359.	119693.	57567.0	57567.0
Component mole fractions				
Nitrogen	1.00000	1.00000	0.823215E-01	0.823215E-01
Oxygen	0.000000E+00	0.000000E+00	0.874355	0.874355
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.433233E-01	0.433233E-01

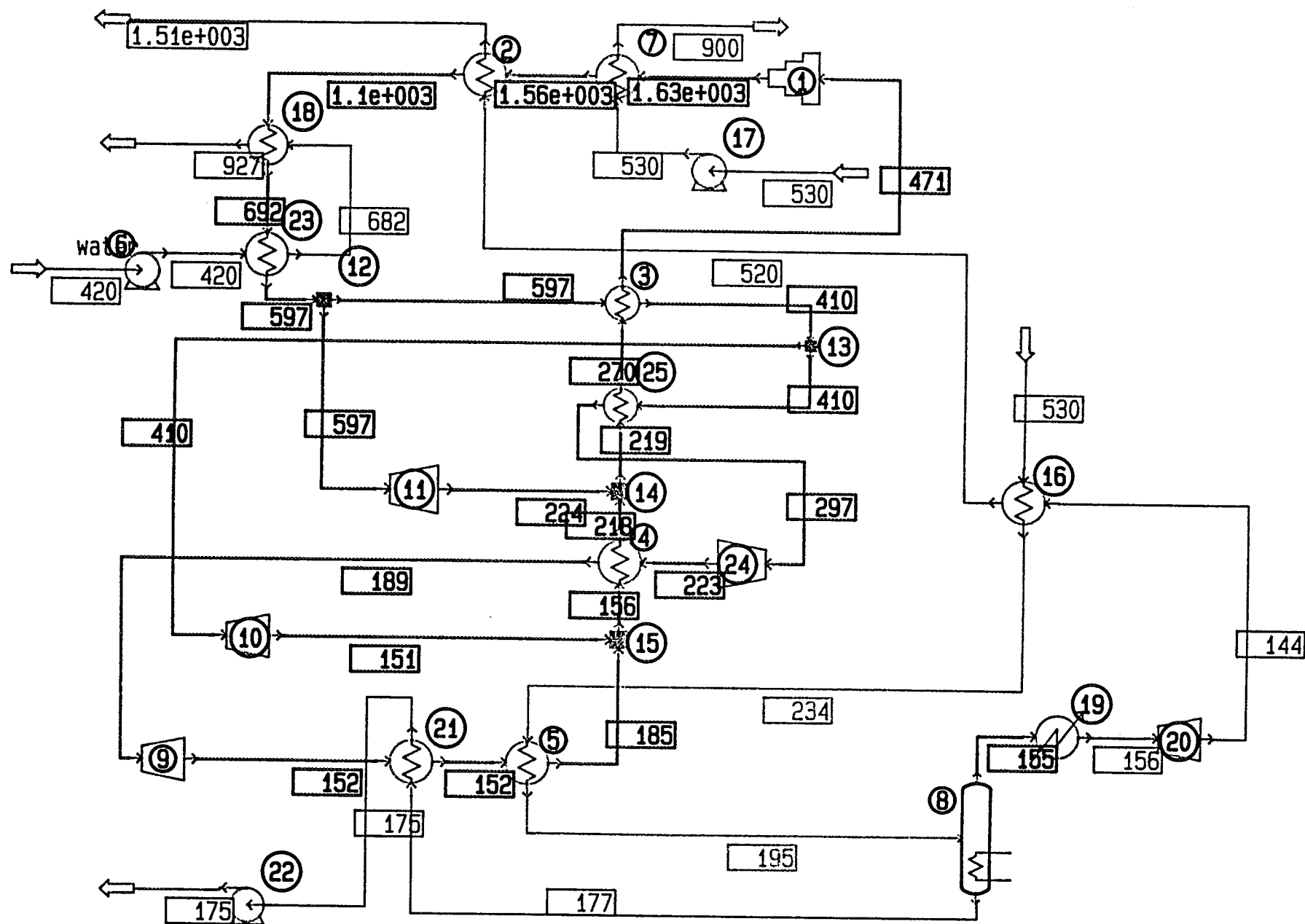
Stream No.	37	38
Name		
Temp R	612.998	682.183
Pres psia	446.000	17.0000
Enth MMBtu/hr	4274.94	-388.236
Vapor mole fraction	1.00000	0.000000E+00
Total lbmol/hr	460359.	55493.9
Component mole fractions		
Nitrogen	1.00000	0.000000E+00
Oxygen	0.000000E+00	0.000000E+00
Water	0.000000E+00	1.00000
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00

JP-4/Slush Cycle
Recycle Pressure 1500 to 26 PSIA
Stream and Equipment Numbers



CASE 3

JP-4/Slush Cycle
Recycle Pressure 1500 to 26 PSIA
Stream Temperatures



Filename : LIN1500A.TLK

Date: 9-Apr-92 Time: 8:33 am

SINGLE COMPRESSOR AND THREE EXPANDERS

FLOWSHEET SUMMARY

Equipment	Stream Numbers
1 COMP	16 -1
2 HTXR	23 22 -2 -32
3 HTXR	3 41 -6 -16
4 HTXR	39 13 -10 -14
5 HTXR	34 18 -12 -20
6 PUMP	30 -31
7 HTXR	1 25 -23 -26
8 CSEP	20 -19 -21
9 EXPN	10 -11
10 EXPN	8 -9
11 EXPN	4 -5
12 DIVI	37 -4 -3
13 DIVI	6 -8 -7
14 MIXE	14 5 -15
15 MIXE	12 9 -13
16 HTXR	28 17 -22 -18
17 PUMP	24 -25
18 HTXR	38 2 -29 -33
19 HTXR	19 -27
20 EXPN	27 -28
21 HTXR	11 21 -34 -35
22 PUMP	35 -36
23 HTXR	31 33 -38 -37
24 EXPN	40 -39
25 HTXR	7 15 -40 -41

Stream Connections

Stream	Equipment From	To	Stream	Equipment From	To	Stream	Equipment From	To
1	1	7	15	14	25	29	18	
2	2	18	16	3	1	30		6
3	12	3	17		16	31	6	23
4	12	11	18	16	5	32	2	
5	11	14	19	8	19	33	18	23
6	3	13	20	5	8	34	21	5
7	13	25	21	8	21	35	21	22
8	13	10	22	16	2	36	22	
9	10	15	23	7	2	37	23	12
10	4	9	24		17	38	23	18
11	9	21	25	17	7	39	24	4
12	5	15	26	7		40	25	24
13	15	4	27	19	20	41	25	3
14	4	14	28	20	16			

Recycle Sequence

23 12 11 14 25 24 3 13 10 15 4 9 21 5 8 19 20

Recycle Sequence

16 1 7 2 18

Cut Streams

33 14 12 18 21 7

Accelerated Streams

33 14 12 18 21 7

Dominant Eigenvalue Method, frequency = 4

Recycle calculations have converged

COMPONENTS

46 47 62 39 98

THERMODYNAMICS

K-value model :Peng-Robinson

Enthalpy model :Peng-Robinson

Liquid density :API

Water miscible

Divider Summary

Equipment name	12	13
number		
Mode	0	1
	Ratio	lbmol/hr
Flow rate/ratio	0.100000	0.000000E+00
Flow rate/ratio	0.900000	120000.

Component Separator Summary

Equipment name	
number	8
P out / del P psia	35.0000
Top temp. mode	2
	Dew point
Top spec. value R	
Bottom temp. mode	2
	Dew point
Bottom spec. value R	
Component split mode	1
Split destination	Bottom
	lbmol/hr
Nitrogen	4739.00
Oxygen	50334.0
Water	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00
Argon	2494.00

Mixer Summary

Equipment name		
number	14	15
Outlet pres. psia	P-out = P-in	P-out = P-in

Heat Exchanger Summary

Equipment name	number	2	3	4	5
Delta P str 1 psia		1.00000	1.00000	1.00000	1.00000
Delta P str 2 psia		1.00000	1.00000	1.00000	1.00000
T str 1 out R			410.000		
Vapor fraction 2 out					1.00000
Min. approach temp. F	50.0000			5.00000	
Case flag	Design	Design	Design	Design	Design
HTC Btu/ft2-hr-F	20.0000	20.0000	20.0000	20.0000	50.0000
Calc. duty MMBtu/hr	1494.80	608.835	179.671	89.7276	
Calc. LMTD F	215.874	132.745	14.9407	46.0976	
Calc. LMTD factor	1.00000	1.00000	1.00000	1.00000	
Utility option flag	0	0	0	0	
Calc area ft2	346222.	229325.	601279.	38929.4	
	$H = 50$	50	50	100	
	$A = 138489$	91730	240512	19465	

Heat Exchanger Summary

Equipment name	number	7	16	18	19
Delta P str 1 psia		1.00000	1.00000	1.00000	0.000000E+00
Delta P str 2 psia		2.00000	1.00000	1.00000	0.000000E+00
T str 2 out R		900.000			
Min. approach temp. F			10.0000	10.0000	
Spec. duty MMBtu/hr					1.00000
Case flag	Design	Design	Design	Design	Design
HTC Btu/ft2-hr-F	50.0000	20.0000	50.0000		
Calc. duty MMBtu/hr	225.172	583.307	1295.74		1.00000
Calc. LMTD F	870.761	36.4765	56.8770		
Calc. LMTD factor	1.00000	1.00000	1.00000		
Utility option flag	0	0	0		0
Calc area ft2	5171.84	799566.	455630.		
	$H = 100$	50	100		
	$A = 2586$	319326	227315		

Heat Exchanger Summary

Equipment name	number	21	23	25
Delta P str 1 psia		0.000000E+00	1.00000	1.00000
Delta P str 2 psia		0.000000E+00	1.00000	1.00000
T str 1 out R				296.500
Str 1 out subcooled F			0.500000	
Case flag	Design	Design	Design	
HTC Btu/ft2-hr-F	1400.00	30.0000	20.0000	
Calc. duty MMBtu/hr	158.822	316.052	159.493	
Calc. LMTD F	24.2071	58.0250	105.631	
Calc. LMTD factor	1.00000	1.00000	1.00000	
Utility option flag	0	0	0	
Calc area ft2	4686.39	181561.	75495.4	
	$H = 70$	50		
	$A = 77812$	30198		

Pump Summary

Equipment name	6	17	22
number			
Output pres. psia	18.0000		150.000
P increase psia		50.0000	
Pump efficiency	0.850000	0.000000E+00	0.850000
Work required			
Kw	3.82768	40.7976	202.372

Compressor Summary

Equipment name	1
number	
Mode	0
	P-out/ eff.
Pout or ratio psia	1500.00
Comp. or Exp. type	Adiabatic
Efficiency	0.850000
Work	
Actual Kw	0.105960E+07
Theor. Kw	900660.
Cp/Cv	1.40249

Expander Summary

Equipment name	9	10	11	20
number	0	0	0	0
Mode	P-out/ eff.	P-out/ eff.	P-out/ eff.	P-out/ eff.
Pout or ratio psia	30.0000	29.0000	28.0000	18.0000
Comp. or Exp. type	Adiabatic	Adiabatic	Adiabatic	Adiabatic
Efficiency	0.850000	0.900000	0.900000	0.900000
Work				
Actual Kw	-3000.50	-112934.	-30380.2	-10002.0
Theor. Kw	-3530.00	-125483.	-33755.8	-11113.4
Cp/Cv	1.98038	1.75933	1.54274	1.39941

Expander Summary

Equipment name	24
number	0
Mode	P-out/ eff.
Pout or ratio psia	446.000
Comp. or Exp. type	Adiabatic
Efficiency	0.900000
Work	
Actual Kw	-10258.9
Theor. Kw	-11398.7
Cp/Cv	2.60134

STREAM PROPERTIES

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Stream No.	1	2	3	4
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	1	2	12	12
To Eqp #	7	18	3	11
lbmol/hr	428373.	428373.	385536.	42837.4
Temp R	1628.43	1098.58	596.573	596.573
Pres psia	1500.00	1498.00	1496.00	1496.00
Enth MMBtu/hr	7197.99	5478.01	3479.60	386.623
Cp Vap Btu/lb-R	0.277034	0.265003	0.280651	0.280666
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.120000E+08	0.120000E+08	0.108000E+08	0.120000E+07
Std Vap ft3/hr	0.162558E+09	0.162558E+09	0.146303E+09	0.162559E+08
Actual ft3/hr	0.514741E+07	0.349933E+07	0.166392E+07	184880.
lb/ft3	2.33127	3.42923	6.49071	6.49071
Cp/Cv	1.36148	1.41586	1.54265	1.54274
Compress. factor	1.03155	1.03811	1.00864	1.00864
Th cond Btu/hr-ft-F	0.365610E-01	0.272109E-01	0.185264E-01	0.185264E-01
Visc cp	0.394848E-01	0.307515E-01	0.212039E-01	0.212039E-01

Stream No.	5	6	7	8
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	11	3	13	13
To Eqp #	14	13	25	10
lbmol/hr	42837.4	385536.	120000.	265536.
Temp R	224.452	410.000	410.000	410.000
Pres psia	28.0000	1495.00	1495.00	1495.00
Enth MMBtu/hr	282.896	2870.77	893.540	1977.23
Cp Vap Btu/lb-R	0.260906	0.339033	0.339043	0.339046
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.120000E+07	0.108000E+08	0.336156E+07	0.743847E+07
Std Vap ft3/hr	0.162559E+08	0.146303E+09	0.455374E+08	0.100765E+09
Actual ft3/hr	0.360150E+07	0.102403E+07	318733.	705294.
lb/ft3	0.333196	10.5466	10.5466	10.5466
Cp/Cv	1.40195	1.75926	1.75931	1.75933
Compress. factor	0.977453	0.902617	0.902617	0.902617
Th cond Btu/hr-ft-F	0.675011E-02	0.173655E-01	0.173655E-01	0.173655E-01
Visc cp	0.845324E-02	0.181807E-01	0.181807E-01	0.181807E-01

STREAM PROPERTIES

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Stream No.	9	10	11	12
Name				
Phase	Mixed	Liquid	Mixed	Vapor
From Eqp #	10	4	9	5
To Eqp #	15	9	21	15
lbmol/hr	265536.	120000.	120000.	120000.
Temp R	150.899	189.433	151.514	185.269
Pres psia	29.0000	445.000	30.0000	29.0000
Enth MMBtu/hr	1591.64	519.349	509.105	757.654
Cp Vap Btu/lb-R	0.275025		0.275535	0.266429
Cp Liq Btu/lb-R	0.498063	0.597437	0.499236	
Mol Fraction Vapor	0.974312	0.000000E+00	0.213200	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Liquid only - -				
lb/hr	191076.	0.336156E+07	0.264488E+07	
Std Liq bbl/hr	675.215	11878.9	9346.31	
Sp Gr	0.807463	0.807463	0.807463	
Actual bbl/hr	703.337	14647.6	9756.62	
lb/bbl	271.650	229.478	271.064	
Sf tens dyne/cm	7.44043	3.09638	7.36580	
Th cond Btu/hr-ft-F	0.714927E-01	0.519424E-01	0.711611E-01	
Visc cp	0.129313	0.801244E-01	0.128163	
- - Vapor only - -				
lb/hr	0.724740E+07		716685.	0.336156E+07
Std Vap ft3/hr	0.981770E+08		0.970859E+07	0.455374E+08
Actual ft3/hr	0.134601E+08		0.128952E+07	0.790149E+07
lb/ft3	0.538437		0.555779	0.425434
Cp/Cv	1.39133		1.39247	1.40054
Compress. factor	0.931829		0.930094	0.960555
Th cond Btu/hr-ft-F	0.459775E-02		0.461647E-02	0.562476E-02
Visc cp	0.582220E-02		0.584999E-02	0.711382E-02

Stream No.	13	14	15	16
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	15	4	14	3
To Eqp #	4	14	25	1
lbmol/hr	385536.	385536.	428373.	428373.
Temp R	156.080	218.380	218.985	470.681
Pres psia	29.0000	28.0000	28.0000	26.0000
Enth MMBtu/hr	2349.34	2529.01	2811.90	3580.22
Cp Vap Btu/lb-R	0.273303	0.261546	0.261461	0.250304
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.108000E+08	0.108000E+08	0.120000E+08	0.120000E+08
Std Vap ft3/hr	0.146303E+09	0.146303E+09	0.162558E+09	0.162558E+09
Actual ft3/hr	0.208768E+08	0.314791E+08	0.350803E+08	0.830738E+08
lb/ft3	0.517322	0.343085	0.342073	0.144450
Cp/Cv	1.39381	1.40184	1.40175	1.40249
Compress. factor	0.937672	0.975669	0.975855	0.998365
Th cond Btu/hr-ft-F	0.475515E-02	0.657862E-02	0.659575E-02	0.130666E-01
Visc cp	0.601998E-02	0.823735E-02	0.825894E-02	0.160177E-01

STREAM PROPERTIES

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Stream No.	17	18	19	20
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	Feed	16	8	5
To Eqp #	16	5	19	8
lbmol/hr	267010.	267010.	209443.	267010.
Temp R	530.000	234.010	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.04	1272.55	1653.30
Cp Vap Btu/lb-R	0.245325	0.282604	0.276412	0.323243
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.9594	28.9594	28.1194	28.9594
- - Vapor only - -				
lb/hr	0.773243E+07	0.773243E+07	0.588941E+07	0.773243E+07
Std Vap ft3/hr	0.101324E+09	0.101324E+09	0.794790E+08	0.101324E+09
Actual ft3/hr	0.100667E+08	0.397563E+07	0.921004E+07	0.300095E+07
lb/ft3	0.768123	1.94496	0.639456	2.57666
Cp/Cv	1.42048	1.50970	1.39930	1.60612
Compress. factor	0.994430	0.883550	0.922840	0.794717
Th cond Btu/hr-ft-F	0.155731E-01	0.197002E-01	0.472026E-02	0.577826E-02
Visc cp	0.181834E-01	0.948710E-02	0.603960E-02	0.820662E-02
Stream No.	21	22	23	24
Name				
Phase	Vapor	Vapor	Vapor	Liquid
From Eqp #	8	16	7	Feed
To Eqp #	21	2	2	17
lbmol/hr	57567.0	209443.	428373.	7333.32
Temp R	176.960	520.000	1560.68	530.000
Pres psia	35.0000	17.0000	1499.00	14.7000
Enth MMBtu/hr	355.092	1822.70	6972.81	-4.35064
Cp Vap Btu/lb-R	0.226897	0.248571	0.275285	
Cp Liq Btu/lb-R				0.420476
Mol Fraction Vapor	1.00000	1.00000	1.00000	0.000000E+00
Average Mol Wt	32.0152	28.1194	28.0130	98.1820
- - Liquid only - -				
lb/hr				720000.
Std Liq bbl/hr				2661.89
Sp Gr				0.771791
Actual bbl/hr				2679.27
lb/bbl				268.709
Sf tens dyne/cm				23.3219
Th cond Btu/hr-ft-F				0.645073E-01
Visc cp				0.719906
- - Vapor only - -				
lb/hr	0.184302E+07	0.588941E+07	0.120000E+08	
Std Vap ft3/hr	0.218454E+08	0.794790E+08	0.162558E+09	
Actual ft3/hr	0.293769E+07	0.686981E+08	0.494106E+07	
lb/ft3	0.627372	0.857288E-01	2.42863	
Cp/Cv	1.41844	1.40100	1.36652	
Compress. factor	0.940645	0.999369	1.03249	
Th cond Btu/hr-ft-F	0.477690E-02	0.142360E-01	0.353934E-01	
Visc cp	0.761262E-02	0.173920E-01	0.384358E-01	

STREAM PROPERTIES

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Stream No. Name	25	26	27	28
Phase	Liquid	Vapor	Vapor	Mixed
From Eqp #	17	7	19	20
To Eqp #	7	Product	20	16
lbmol/hr	7333.32	7333.32	209443.	209443.
Temp R	530.162	900.000	156.015	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.40
Cp Vap Btu/lb-R		0.567044	0.276151	0.267927
Cp Liq Btu/lb-R	0.420735			0.474549
Mol Fraction Vapor	0.000000E+00	1.00000	1.00000	0.958409
Average Mol Wt	98.1820	98.1820	28.1194	28.1194
- - Liquid only - -				
lb/hr	720000.			246806.
Std Liq bbl/hr	2661.89			849.764
Sp Gr	0.771791			0.828737
Actual bbl/hr	2678.52			859.988
lb/bbl	268.784			286.966
Sf tens dyne/cm	23.3127			8.67867
Th cond Btu/hr-ft-F	0.644954E-01			0.765438E-01
Visc cp	0.719000			0.151213
- - Vapor only - -				
lb/hr		720000.	0.588941E+07	0.564260E+07
Std Vap ft3/hr		0.278284E+07	0.794790E+08	0.761734E+08
Actual ft3/hr		0.104543E+07	0.925241E+07	0.163940E+08
lb/ft3		0.688710	0.636527	0.344186
Cp/Cv		1.04414	1.39941	1.38063
Compress. factor		0.925595	0.923615	0.953006
Th cond Btu/hr-ft-F		0.196464E-01	0.473798E-02	0.436506E-02
Visc cp		0.110629E-01	0.606179E-02	0.551576E-02

STREAM PROPERTIES

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Stream No.	29	30	31	32
Name		water		
Phase	Vapor	Liquid	Liquid	Vapor
From Eqp #	18	Feed	6	2
To Eqp #	Product	6	23	Product
lbmol/hr	66592.7	66592.7	66592.7	209443.
Temp R	926.862	420.000	419.962	1510.68
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	829.859	-781.948	-781.935	3317.51
Cp Vap Btu/lb-R	0.472693			0.269979
Cp Liq Btu/lb-R		1.00480	1.00480	
Mol Fraction Vapor	1.00000	0.000000E+00	0.000000E+00	1.00000
Average Mol Wt	18.0200	18.0200	18.0200	28.1194
- - Liquid only - -				
lb/hr		0.120000E+07	0.120000E+07	
Std Liq bbl/hr		3426.74	3426.74	
Sp Gr		0.999212	0.999212	
Actual bbl/hr		3237.37	3237.30	
lb/bbl		370.642	370.650	
Sf tens dyne/cm		83.2442	83.2479	
Th cond Btu/hr-ft-F		0.277860	0.277829	
Visc cp		6.66391	6.66994	
- - Vapor only - -				
lb/hr	0.120000E+07			0.588941E+07
Std Vap ft3/hr	0.252705E+08			0.794790E+08
Actual ft3/hr	0.412345E+08			0.212261E+09
lb/ft3	0.291018E-01			0.277461E-01
Cp/Cv	1.31396			1.35372
Compress. factor	0.996184			1.00035
Th cond Btu/hr-ft-F	0.217423E-01			0.340678E-01
Visc cp	0.179145E-01			0.372263E-01

STREAM PROPERTIES

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Stream No.	33	34	35	36
Name				
Phase	Vapor	Mixed	Liquid	Liquid
From Eqp #	18	21	21	22
To Eqp #	23	5	22	Product
lbmol/hr	428373.	120000.	57567.0	57567.0
Temp R	692.183	151.514	174.523	175.319
Pres psia	1497.00	30.0000	35.0000	150.000
Enth MMBtu/hr	4182.27	667.926	196.270	196.961
Cp Vap Btu/lb-R	0.271573	0.275542		
Cp Liq Btu/lb-R		0.499253	0.402192	0.394778
Mol Fraction Vapor	1.00000	0.787276	0.100000E-05	0.000000E+00
Average Mol Wt	28.0130	28.0130	32.0152	32.0152
- - Liquid only - -				
lb/hr		715084.	0.184302E+07	0.184302E+07
Std Liq bbl/hr		2526.92	5084.39	5084.39
Sp Gr		0.807463	1.03431	1.03431
Actual bbl/hr		2637.86	4911.61	4922.89
lb/bbl		271.064	375.209	374.349
Sf tens dyne/cm		7.36580	10.4225	10.3174
Th cond Btu/hr-ft-F		0.711611E-01	0.771448E-01	0.768175E-01
Visc cp		0.128163	0.161782	0.160421
- - Vapor only - -				
lb/hr	0.120000E+08	0.264648E+07		
Std Vap ft3/hr	0.162558E+09	0.358505E+08		
Actual ft3/hr	0.217857E+07	0.476174E+07		
lb/ft3	5.50821	0.555779		
Cp/Cv	1.50126	1.39250		
Compress. factor	1.02506	0.930094		
Th cond Btu/hr-ft-F	0.199939E-01	0.461647E-02		
Visc cp	0.230860E-01	0.584999E-02		

STREAM PROPERTIES

Stream No.	37	38	39	
Name				
Phase	Vapor	Liquid	Mixed	V
From Eqp #	23	23	24	
To Eqp #	12	18	4	
lbmol/hr	428374.	66592.7	120000.	1
Temp R	596.573	682.183	223.380	2
Pres psia	1496.00	17.0000	446.000	1
Enth MMBtu/hr	3866.23	-465.884	699.020	7
Cp Vap Btu/lb-R	0.280660		1.94876	0.
Cp Liq Btu/lb-R		1.00411	5.08671	
Mol Fraction Vapor	1.00000	0.000000E+00	0.998375	1
Average Mol Wt	28.0130	18.0200	28.0130	2
- - Liquid only - -				
lb/hr		0.120000E+07	5461.74	
Std Liq bbl/hr		3426.74	19.3001	
Sp Gr		0.999212	0.807463	
Actual bbl/hr		3757.54	33.8740	
lb/bbl		319.333	161.222	
Sf tens dyne/cm		57.4976	0.221662	
Th cond Btu/hr-ft-F		0.394885	0.267095E-01	
Visc cp		0.262520	0.349645E-01	
- - Vapor only - -				
lb/hr	0.120000E+08		0.335610E+07	0.
Std Vap ft3/hr	0.162559E+09		0.454634E+08	0.
Actual ft3/hr	0.184880E+07		281888.	1
lb/ft3	6.49071		11.9058	2
Cp/Cv	1.54271		7.99242	2
Compress. factor	1.00864		0.437816	0.
Th cond Btu/hr-ft-F	0.185264E-01		0.301021E-01	0.
Visc cp	0.212039E-01		0.130175E-01	0.

Stream No.	41
Name	
Phase	Vapor
From Eqp #	25
To Eqp #	3
lbmol/hr	428373.
Temp R	270.158
Pres psia	27.0000
Enth MMBtu/hr	2971.39
Cp Vap Btu/lb-R	0.257045
Mol Fraction Vapor	1.00000
Average Mol Wt	28.0130
- - Vapor only - -	
lb/hr	0.120000E+08
Std Vap ft3/hr	0.162558E+09
Actual ft3/hr	0.454038E+08
lb/ft3	0.264295
Cp/Cv	1.40169
Compress. factor	0.987225
Th cond Btu/hr-ft-F	0.801078E-02
Visc cp	0.100240E-01

FLOW SUMMARIES

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Stream No. Name	1	2	3	4
Temp R	1628.43	1098.58	596.573	596.573
Pres psia	1500.00	1498.00	1496.00	1496.00
Enth MMBtu/hr	7197.99	5478.01	3479.60	386.623
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	428373.	428373.	385536.	42837.4
Flowrates in lbmol/hr				
Nitrogen	428373.	428373.	385536.	42837.4
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	5	6	7	8
Temp R	224.452	410.000	410.000	410.000
Pres psia	28.0000	1495.00	1495.00	1495.00
Enth MMBtu/hr	282.896	2870.77	893.540	1977.23
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	42837.4	385536.	120000.	265536.
Flowrates in lbmol/hr				
Nitrogen	42837.4	385536.	120000.	265536.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	9	10	11	12
Temp R	150.899	189.433	151.514	185.269
Pres psia	29.0000	445.000	30.0000	29.0000
Enth MMBtu/hr	1591.64	519.349	509.105	757.654
Vapor mole fraction	0.974312	0.000000E+00	0.213200	1.00000
Total lbmol/hr	265536.	120000.	120000.	120000.
Flowrates in lbmol/hr				
Nitrogen	265536.	120000.	120000.	120000.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	13	14	15	16
Temp R	156.080	218.380	218.985	470.681
Pres psia	29.0000	28.0000	28.0000	26.0000
Enth MMBtu/hr	2349.34	2529.01	2811.90	3580.22
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	385536.	385536.	428373.	428373.
Flowrates in lbmol/hr				
Nitrogen	385536.	385536.	428373.	428373.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

FLOW SUMMARIES

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Stream No.	17	18	19	20
Name				
Temp R	530.000	234.010	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.04	1272.55	1653.30
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	267010.	267010.	209443.	267010.
Flowrates in lbmol/hr				
Nitrogen	208589.	208589.	203850.	208589.
Oxygen	55926.7	55926.7	5592.75	55926.7
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	2493.99	2493.99	0.000000E+00	2493.99
Stream No.	21	22	23	24
Name				
Temp R	176.960	520.000	1560.68	530.000
Pres psia	35.0000	17.0000	1499.00	14.7000
Enth MMBtu/hr	355.092	1822.70	6972.81	-4.35064
Vapor mole fraction	1.00000	1.00000	1.00000	0.000000E+00
Total lbmol/hr	57567.0	209443.	428373.	7333.32
Flowrates in lbmol/hr				
Nitrogen	4739.00	203850.	428373.	0.000000E+00
Oxygen	50334.0	5592.75	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	7333.32
Argon	2493.99	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	25	26	27	28
Name				
Temp R	530.162	900.000	156.015	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.40
Vapor mole fraction	0.000000E+00	1.00000	1.00000	0.958409
Total lbmol/hr	7333.32	7333.32	209443.	209443.
Flowrates in lbmol/hr				
Nitrogen	0.000000E+00	0.000000E+00	203850.	203850.
Oxygen	0.000000E+00	0.000000E+00	5592.75	5592.75
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	7333.32	7333.32	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	29	30	31	32
Name		water		
Temp R	926.862	420.000	419.962	1510.68
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	829.859	-781.948	-781.935	3317.51
Vapor mole fraction	1.00000	0.000000E+00	0.000000E+00	1.00000
Total lbmol/hr	66592.7	66592.7	66592.7	209443.
Flowrates in lbmol/hr				
Nitrogen	0.000000E+00	0.000000E+00	0.000000E+00	203850.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	5592.75
Water	66592.7	66592.7	66592.7	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

FLOW SUMMARIES

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Stream No.	33	34	35	36
Name				
Temp R	692.183	151.514	174.523	175.319
Pres psia	1497.00	30.0000	35.0000	150.000
Enth MMBtu/hr	4182.27	667.926	196.270	196.961
Vapor mole fraction	1.00000	0.787276	0.100000E-05	0.000000E+00
Total lbmol/hr	428373.	120000.	57567.0	57567.0
Flowrates in lbmol/hr				
Nitrogen	428373.	120000.	4739.00	4739.00
Oxygen	0.000000E+00	0.000000E+00	50334.0	50334.0
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	2493.99	2493.99

Stream No.	37	38	39	40
Name				
Temp R	596.573	682.183	223.380	296.500
Pres psia	1496.00	17.0000	446.000	1494.00
Enth MMBtu/hr	3866.23	-465.884	699.020	734.047
Vapor mole fraction	1.00000	0.000000E+00	0.998375	1.00000
Total lbmol/hr	428374.	66592.7	120000.	120000.
Flowrates in lbmol/hr				
Nitrogen	428374.	0.000000E+00	120000.	120000.
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	66592.7	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

Stream No.	41
Name	
Temp R	270.158
Pres psia	27.0000
Enth MMBtu/hr	2971.39
Vapor mole fraction	1.00000
Total lbmol/hr	428373.
Flowrates in lbmol/hr	
Nitrogen	428373.
Oxygen	0.000000E+00
Water	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00
Argon	0.000000E+00

FLOW SUMMARIES

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Stream No.	1	2	3	4
Name				
Temp R	1628.43	1098.58	596.573	596.573
Pres psia	1500.00	1498.00	1496.00	1496.00
Enth MMBtu/hr	7197.99	5478.01	3479.60	386.623
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	428373.	428373.	385536.	42837.4
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	5	6	7	8
Name				
Temp R	224.452	410.000	410.000	410.000
Pres psia	28.0000	1495.00	1495.00	1495.00
Enth MMBtu/hr	282.896	2870.77	893.540	1977.23
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	42837.4	385536.	120000.	265536.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	9	10	11	12
Name				
Temp R	150.899	189.433	151.514	185.269
Pres psia	29.0000	445.000	30.0000	29.0000
Enth MMBtu/hr	1591.64	519.349	509.105	757.654
Vapor mole fraction	0.974312	0.000000E+00	0.213200	1.00000
Total lbmol/hr	265536.	120000.	120000.	120000.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	13	14	15	16
Name				
Temp R	156.080	218.380	218.985	470.681
Pres psia	29.0000	28.0000	28.0000	26.0000
Enth MMBtu/hr	2349.34	2529.01	2811.90	3580.22
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	385536.	385536.	428373.	428373.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

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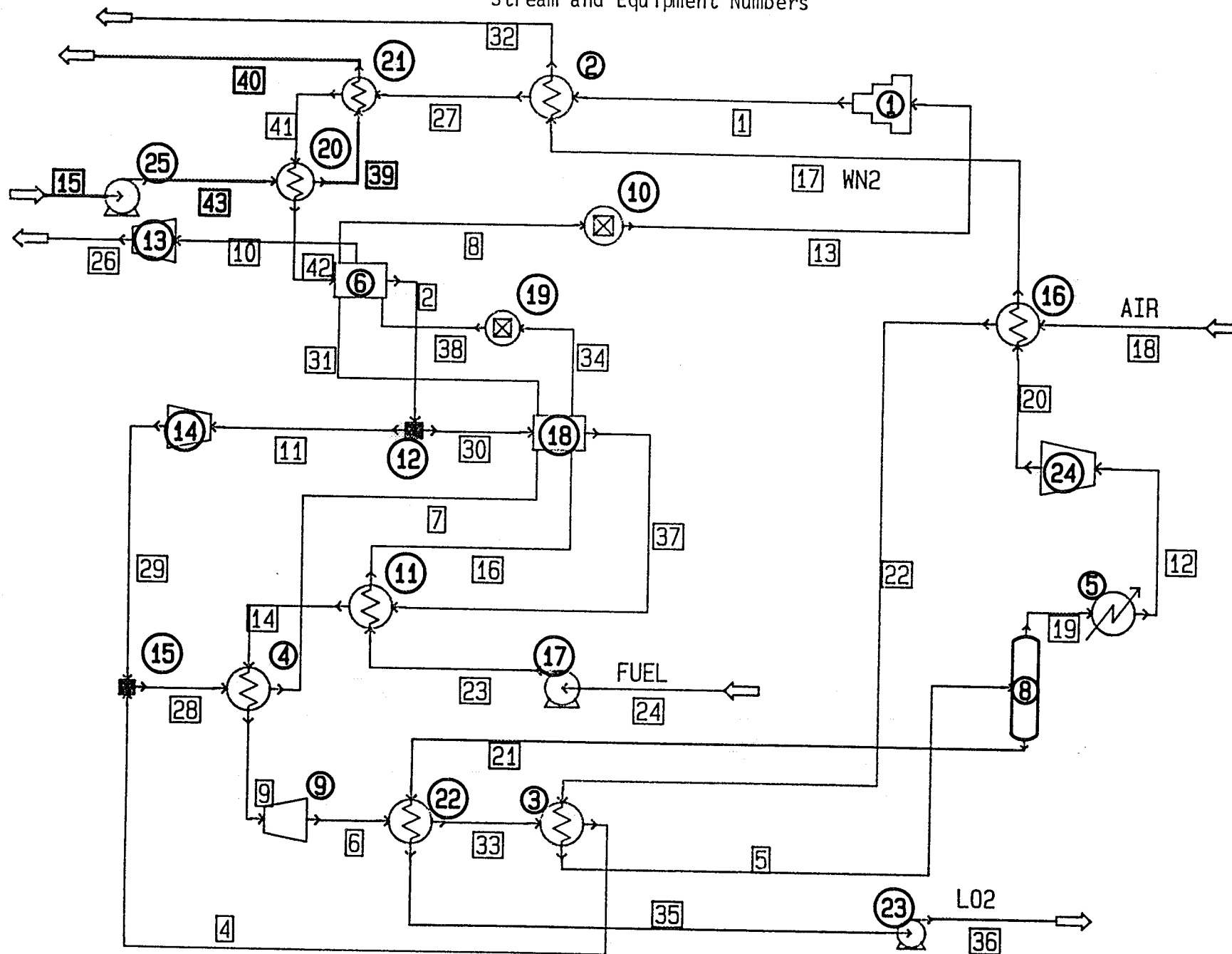
Stream No. Name	17	18	19	20
Temp R	530.000	234.010	155.431	195.066
Pres psia	150.000	149.000	35.0000	148.000
Enth MMBtu/hr	2326.35	1743.04	1272.55	1653.30
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	267010.	267010.	209443.	267010.
Component mole fractions				
Nitrogen	0.781204	0.781204	0.973297	0.781204
Oxygen	0.209456	0.209456	0.267030E-01	0.209456
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.934046E-02	0.934046E-02	0.000000E+00	0.934046E-02
Stream No. Name	21	22	23	24
Temp R	176.960	520.000	1560.68	530.000
Pres psia	35.0000	17.0000	1499.00	14.7000
Enth MMBtu/hr	355.092	1822.70	6972.81	-4.35064
Vapor mole fraction	1.00000	1.00000	1.00000	0.000000E+00
Total lbmol/hr	57567.0	209443.	428373.	7333.32
Component mole fractions				
Nitrogen	0.823215E-01	0.973297	1.00000	0.000000E+00
Oxygen	0.874355	0.267030E-01	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	1.00000
Argon	0.433233E-01	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	25	26	27	28
Temp R	530.162	900.000	156.015	143.763
Pres psia	64.7000	62.7000	35.0000	18.0000
Enth MMBtu/hr	-4.21135	220.961	1273.55	1239.40
Vapor mole fraction	0.000000E+00	1.00000	1.00000	0.958409
Total lbmol/hr	7333.32	7333.32	209443.	209443.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	0.973297	0.973297
Oxygen	0.000000E+00	0.000000E+00	0.267030E-01	0.267030E-01
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	1.00000	1.00000	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	29	30	31	32
Temp R	926.862	420.000	419.962	1510.68
Pres psia	16.0000	14.7000	18.0000	16.0000
Enth MMBtu/hr	829.859	-781.948	-781.935	3317.51
Vapor mole fraction	1.00000	0.000000E+00	0.000000E+00	1.00000
Total lbmol/hr	66592.7	66592.7	66592.7	209443.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	0.000000E+00	0.973297
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.267030E-01
Water	1.00000	1.00000	1.00000	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00

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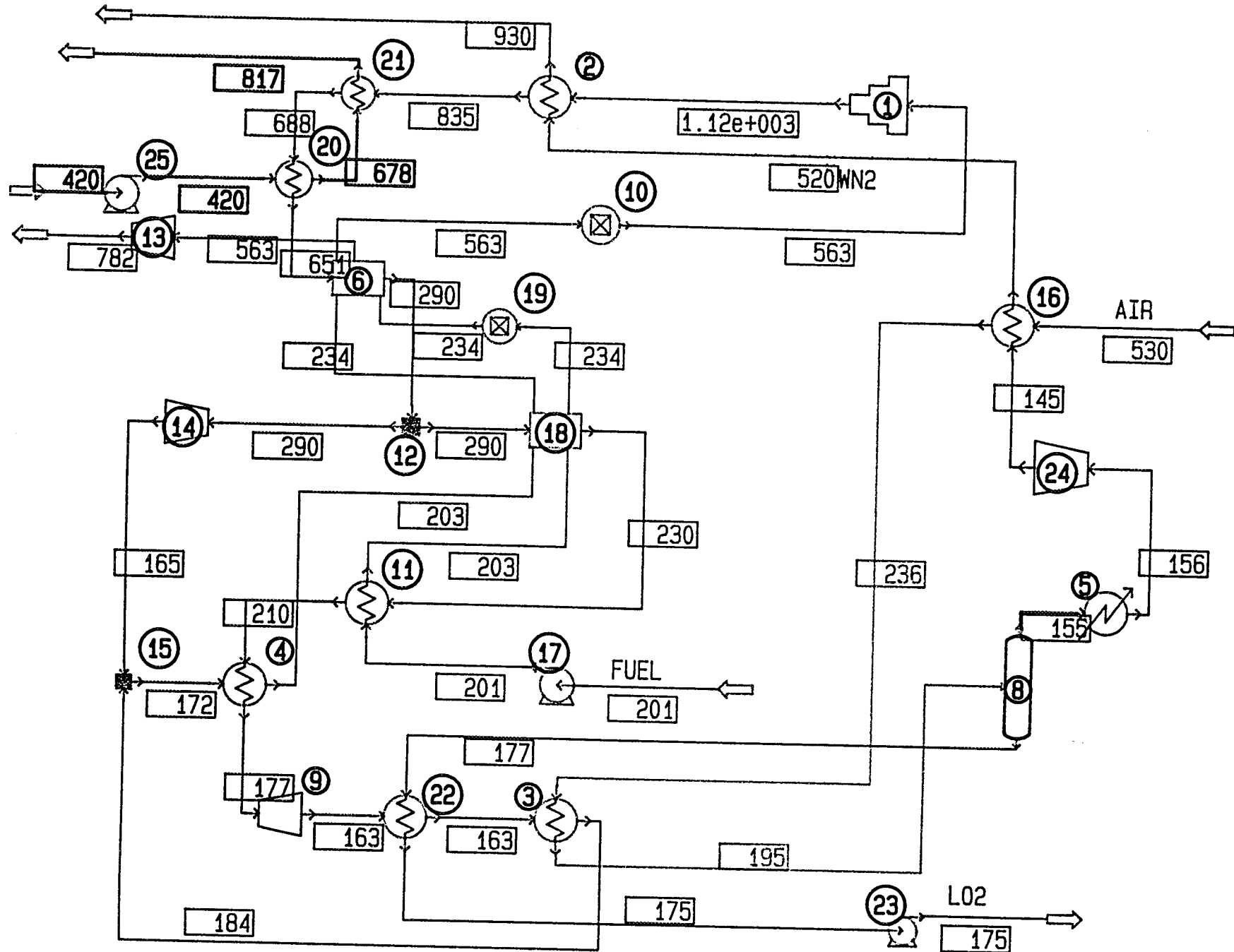
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Stream No.	33	34	35	36
Name				
Temp R	692.183	151.514	174.523	175.319
Pres psia	1497.00	30.0000	35.0000	150.000
Enth MMBtu/hr	4182.27	667.926	196.270	196.961
Vapor mole fraction	1.00000	0.787276	0.100000E-05	0.000000E+00
Total lbmol/hr	428373.	120000.	57567.0	57567.0
Component mole fractions				
Nitrogen	1.00000	1.00000	0.823215E-01	0.823215E-01
Oxygen	0.000000E+00	0.000000E+00	0.874355	0.874355
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.433233E-01	0.433233E-01
Stream No.	37	38	39	40
Name				
Temp R	596.573	682.183	223.380	296.500
Pres psia	1496.00	17.0000	446.000	1494.00
Enth MMBtu/hr	3866.23	-465.884	699.020	734.047
Vapor mole fraction	1.00000	0.000000E+00	0.998375	1.00000
Total lbmol/hr	428374.	66592.7	120000.	120000.
Component mole fractions				
Nitrogen	1.00000	0.000000E+00	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	1.00000	0.000000E+00	0.000000E+00
Methyl-Cyclo-C6	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	41			
Name				
Temp R	270.158			
Pres psia	27.0000			
Enth MMBtu/hr	2971.39			
Vapor mole fraction	1.00000			
Total lbmol/hr	428373.			
Component mole fractions				
Nitrogen	1.00000			
Oxygen	0.000000E+00			
Water	0.000000E+00			
Methyl-Cyclo-C6	0.000000E+00			
Argon	0.000000E+00			

CASE 4
LIQUID METHANE CYCLE
Stream and Equipment Numbers



CASE 4
Liquid Methane Cycle
Stream Temperatures



CHEMCAD 2 Version 2.5

Filename : LIN500M.TLK

Date: 9-Apr-92 Time: 8:28 am

SINGLE COMPRESSOR AND THREE EXPANDERS

FLOWSHEET SUMMARY

Equipment	Stream Numbers
1 COMP	13 -1
2 HTXR	1 17 -27 -32
3 HTXR	33 22 -4 -5
4 HTXR	28 14 -7 -9
5 HTXR	19 -12
6 LNGH	42 31 38 -2 -8 -10
8 CSEP	5 -19 -21
9 EXPN	9 -6
10 CONT	8 -13
11 HTXR	37 23 -14 -16
12 DIVI	2 -11 -30
13 COMP	10 -26
14 EXPN	11 -29
15 MIXE	29 4 -28
16 HTXR	18 20 -22 -17
17 PUMP	24 -23
18 LNGH	30 7 16 -37 -31 -34
19 CONT	34 -38
20 HTXR	43 41 -39 -42
21 HTXR	27 39 -41 -40
22 HTXR	6 21 -33 -35
23 PUMP	35 -36
24 EXPN	12 -20
25 PUMP	15 -43

Stream Connections

Stream	Equipment		Stream	Equipment		Stream	Equipment	
	From	To		From	To		From	To
1	1	2	16	11	18	31	18	6
2	6	12	17	16	2	32	2	
4	3	15	18		16	33	22	3
5	3	8	19	8	5	34	18	19
6	9	22	20	24	16	35	22	23
7	4	18	21	8	22	36	23	
8	6	10	22	16	3	37	18	11
9	4	9	23	17	11	38	19	6
10	6	13	24		17	39	20	21
11	12	14	26	13		40	21	
12	5	24	27	2	21	41	21	20
13	10	1	28	15	4	42	20	6
14	11	4	29	14	15	43	25	20
15	0	25	30	12	18			

Recycle Sequence

12 14 15 4 9 22 18 19 11 3 8 5 24 16 2 21 20

Recycle Sequence

6 10 1

Cut Streams

2 1 4 16 21 22 39 14

Accelerated Streams

2 1 4 16 21 22 39 14

Dominant Eigenvalue Method, frequency = 4

Recycle calculations have converged

COMPONENTS

46 47 62 98 2

THERMODYNAMICS

K-value model :Peng-Robinson

Enthalpy model :Peng-Robinson

Liquid density :API

Water miscible

Divider Summary

Equipment name	
number	12
Mode	0
	Ratio
Flow rate/ratio	0.600000
Flow rate/ratio	0.400000

Component Separator Summary

Equipment name	
number	8
P out / del P psia	35.0000
Top temp. mode	2
	Dew point
Top spec. value R	
Bottom temp. mode	2
	Dew point
Bottom spec. value R	
Component split mode	1
Split destination	Bottom
	lbmol/hr
Nitrogen	4739.00
Oxygen	50334.0
Water	0.000000E+00
Argon	2494.00
Methane	0.000000E+00

Mixer Summary

Equipment name	
number	15
Outlet pres. psia	P-out = P-in

Heat Exchanger Summary

Equipment name	number	2	3	4	5
Delta P str 1 psia		1.00000	1.00000	2.00000	0.000000E+00
Delta P str 2 psia		1.00000	1.00000	2.00000	0.000000E+00
Vapor fraction 2 out			0.999990		
Min. approach temp. F		190.000		5.00000	
Spec. duty MMBtu/hr					1.00000
Case flag	Design		Design	Design	Design
HTC Btu/ft2-hr-F		20.0000	20.0000	100.000	
Calc. duty MMBtu/hr		603.272	95.0292	70.1774	1.00000
Calc. LMTD F		247.303	41.1874	6.05751	
Calc. LMTD factor		1.00000	1.00000	1.00000	
Utility option flag		0	0	0	0
Calc area ft2		121970.	115362.	115852.	
	H =	50	50		
	A =	48788	46145		

Heat Exchanger Summary

Equipment name	number	11	16	20	21
Delta P str 1 psia		1.00000	2.00000	3.00000	1.00000
Delta P str 2 psia		2.00000	2.00000	1.00000	1.00000
Min. approach temp. F			10.0000		10.0000
Str 1 out subcooled F				5.00000	
Case flag	Design		Design	Design	Design
HTC Btu/ft2-hr-F		50.0000	20.0000	30.0000	50.0000
Calc. duty MMBtu/hr		161.618	578.018	77.6556	309.780
Calc. LMTD F		16.4806	36.6268	70.3364	13.6570
Calc. LMTD factor		1.00000	1.00000	1.00000	1.00000
Utility option flag		0	0	0	0
Calc area ft2		196131.	789065.	36802.0	453660.
	H =	100	50	70	100
	A =	98066	315625	15772	226830

Heat Exchanger Summary

Equipment name	number	22
Delta P str 1 psia		0.000000E+00
Delta P str 2 psia		0.000000E+00
Case flag	Design	
HTC Btu/ft2-hr-F		1400.00
Calc. duty MMBtu/hr		158.831
Calc. LMTD F		12.2572
Calc. LMTD factor		1.00000
Utility option flag		0
Calc area ft2		9255.84

Pump Summary

Equipment name	17	23	25
number			
Output pres. psia	18.0000	150.000	20.0000
Pump efficiency	0.900000	0.950000	0.850000
Work required			
Kw	5.50282	181.063	1.53803

Controller Summary

Equipment name		
number	10	19
Mode	Feedback	Feedback
Variable no. (adjust)	7	7
Equipment no.	6	18
Stream no.	0	0
Minimum	0.000000E+00	0.000000E+00
Maximum	0.000000E+00	0.000000E+00
Relative step size	0.000000E+00	0.000000E+00
Variable no. (from)	1	1
Scale	1.00000	1.00000
Constant	Stream # 8	Stream # 34
Unit		
Variable no. (of)	1	1
Scale	1.00000	1.00000
Beginning	Stream # 10	Stream # 31
Loop		
Tolerance	0.000000E+00	0.000000E+00

Compressor Summary

Equipment name		
number	1	13
Mode	0	0
P-out or ratio psia	P-out/ eff.	P-out/ eff.
Comp. or Exp. type	425.000	50.0000
Efficiency	Adiabatic	Adiabatic
Work	0.850000	0.850000
Actual Kw	338496.	27448.2
Theor. Kw	287722.	23331.0
Cp/Cv	1.40500	1.29367

LNG Exchanger Summary

Equipment name	number	6	18
Stream 1			
Delta P psia		2.00000	1.00000
Mode		1	1
		T-out deg R	T-out deg R
spec. value		290.000	230.000
Duty MMBtu/hr		-812.091	-80.0378
Stream 2			
Delta P psia		2.00000	1.00000
Mode		1	1
		T-out deg R	T-out deg R
spec. value		563.271	233.997
Duty MMBtu/hr		688.780	68.7763
Stream 3			
Delta P psia		2.00000	1.00000
Mode		0	0
		No spec.	No spec.
spec. value			
Duty MMBtu/hr		123.311	11.2614
Total Q MMBtu/hr		812.091	80.0378
$\approx$ LMTD		70.4	39.7
Area for H=20		677609	100623
Area for H=50		100623	40249
Expander Summary			

Equipment name	number	9	14	24
Mode		0	0	0
		P-out/ eff.	P-out/ eff.	P-out/ eff.
Pout or ratio psia		55.0000	54.0000	20.0000
Comp. or Exp. type		Adiabatic	Adiabatic	Adiabatic
Efficiency		0.800000	0.900000	0.900000
Work				
Actual Kw		-1181.62	-34750.3	-8470.67
Theor. Kw		-1477.02	-38611.5	-9411.85
Cp/Cv		2.12182	1.66993	1.39939

STREAM PROPERTIES

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Stream No.	1	2	4	5
Name				
Phase	Vapor	Vapor	Vapor	Mixed
From Eqp #	1	6	3	3
To Eqp #	2	12	15	8
lbmol/hr	293231.	293231.	117293.	267006.
Temp R	1120.36	290.000	183.523	194.876
Pres psia	425.000	420.000	54.0000	147.000
Enth MMBtu/hr	3795.06	1992.26	734.897	1653.27
Cp Vap Btu/lb-R	0.260385	0.328871	0.278169	0.322585
Mol Fraction Vapor	1.00000	1.00000	1.00000	0.999990
Average Mol Wt	28.0130	28.0130	28.0130	28.9591
- - Liquid only - -				
- - Vapor only - -				
lb/hr	0.821429E+07	0.821429E+07	0.328572E+07	0.773225E+07
Std Vap ft3/hr	0.111275E+09	0.111275E+09	0.445100E+08	0.101323E+09
Actual ft3/hr	0.838059E+07	0.182527E+07	0.394638E+07	0.302226E+07
lb/ft3	0.980157	4.50031	0.832590	2.55846
Cp/Cv	1.38969	1.66993	1.42408	1.60360
Compress. factor	1.01041	0.840174	0.922641	0.795739
Th cond Btu/hr-ft-F	0.269619E-01	0.179775E-01	0.557352E-02	0.577265E-02
Visc cp	0.304998E-01	0.118908E-01	0.713678E-02	0.819440E-02

STREAM PROPERTIES

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Stream No.	6	7	8	9
Name				
Phase	Mixed	Vapor	Vapor	Liquid
From Eqp #	9	4	6	4
To Eqp #	22	18	10	9
lbmol/hr	117293.	293231.	293231.	117293.
Temp R	163.438	202.915	563.271	177.334
Pres psia	55.0000	52.0000	49.0000	416.000
Enth MMBtu/hr	481.037	1881.79	2639.34	485.072
Cp Vap Btu/lb-R	0.288730	0.271371	0.250101	
Cp Liq Btu/lb-R	0.835658			0.546345
Mol Fraction Vapor	0.854528E-01	1.00000	1.00000	0.000000E+00
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Liquid only - -				
lb/hr	0.300494E+07			0.328572E+07
Std Liq gal/min	7433.10			8127.62
Sp Gr	0.807463			0.807463
Actual gal/min	8112.53			9416.98
lb/gal	6.17296			5.81476
Sf tens dyne/cm	5.94871			4.37864
Th cond Btu/hr-ft-F	0.650773E-01			0.582816E-01
Visc cp	0.109590			0.932073E-01
- - Vapor only - -				
lb/hr	280774.	0.821429E+07	0.821429E+07	
Std Vap ft3/hr	0.380351E+07	0.111275E+09	0.111275E+09	
Actual ft3/hr	284683.	0.115888E+08	0.361346E+08	
lb/ft3	0.986270	0.708811	0.227325	
Cp/Cv	1.42709	1.41992	1.40500	
Compress. factor	0.890789	0.943886	0.999061	
Th cond Btu/hr-ft-F	0.497708E-02	0.613712E-02	0.152158E-01	
Visc cp	0.640853E-02	0.782609E-02	0.184256E-01	

Stream No.	10	11	12	13
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	6	12	5	10
To Eqp #	13	14	24	1
lbmol/hr	45591.4	175939.	209439.	293231.
Temp R	563.175	290.000	156.046	563.271
Pres psia	13.0000	420.000	35.0000	49.0000
Enth MMBtu/hr	433.912	1195.36	1273.53	2639.34
Cp Vap Btu/lb-R	0.550413	0.328871	0.276134	0.250101
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	16.0420	28.0130	28.1194	28.0130
- - Vapor only - -				
lb/hr	731378.	0.492857E+07	0.588931E+07	0.821429E+07
Std Vap ft3/hr	0.173010E+08	0.667650E+08	0.794776E+08	0.111275E+09
Actual ft3/hr	0.211568E+08	0.109516E+07	0.925445E+07	0.361346E+08
lb/ft3	0.345694E-01	4.50031	0.636376	0.227325
Cp/Cv	1.29367	1.66993	1.39939	1.40500
Compress. factor	0.998313	0.840174	0.923655	0.999061
Th cond Btu/hr-ft-F	0.207685E-01	0.179775E-01	0.473889E-02	0.152158E-01
Visc cp	0.116023E-01	0.118908E-01	0.606294E-02	0.184256E-01

STREAM PROPERTIES

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Stream No.	14	15	16	17
Name				
Phase	Liquid	Liquid	Vapor	WN2
From Eqp #	11	Feed	11	Vapor
To Eqp #	4	25	18	16
				2
lbmol/hr	117293.	16648.2	45591.4	209439.
Temp R	210.169	420.000	203.267	520.000
Pres psia	418.000	14.6960	16.0000	18.0000
Enth MMBtu/hr	555.249	-195.487	299.339	1822.62
Cp Vap Btu/lb-R			0.496553	0.248553
Cp Liq Btu/lb-R	0.877651	1.00480		
Mol Fraction Vapor	0.000000E+00	0.000000E+00	1.00000	1.00000
Average Mol Wt	28.0130	18.0200	16.0420	28.1194
- - Liquid only - -				
lb/hr	0.328572E+07	300000.		
Std Liq gal/min	8127.62	599.680		
Sp Gr	0.807463	0.999212		
Actual gal/min	11659.0	566.540		
lb/gal	4.69660	8.82478		
Sf tens dyne/cm	1.14629	83.2442		
Th cond Btu/hr-ft-F	0.383476E-01	0.277860		
Visc cp	0.543230E-01	6.66391		
- - Vapor only - -				
lb/hr			731378.	0.588931E+07
Std Vap ft3/hr			0.173010E+08	0.794776E+08
Actual ft3/hr			0.599761E+07	0.648781E+08
lb/ft3			0.121945	0.907750E-01
Cp/Cv			1.34696	1.40086
Compress. factor			0.965048	0.999332
Th cond Btu/hr-ft-F			0.670877E-02	0.142360E-01
Visc cp			0.468808E-02	0.173920E-01

STREAM PROPERTIES

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Stream No.	18	19	20	21
Name	AIR			
Phase	Vapor	Vapor	Mixed	Vapor
From Eqp #	Feed	8	24	8
To Eqp #	16	5	16	22
lbmol/hr	267006.	209439.	209439.	57567.0
Temp R	530.000	155.431	145.490	176.960
Pres psia	150.000	35.0000	20.0000	35.0000
Enth MMBtu/hr	2326.32	1272.53	1244.60	355.092
Cp Vap Btu/lb-R	0.245361	0.276417	0.268903	0.226897
Cp Liq Btu/lb-R			0.477142	
Mol Fraction Vapor	1.00000	1.00000	0.964600	1.00000
Average Mol Wt	28.9594	28.1194	28.1194	32.0152
- - Liquid only - -				
lb/hr			210046.	
Std Liq gal/min			506.349	
Sp Gr			0.828556	
Actual gal/min			515.347	
lb/gal			6.79248	
Sf tens dyne/cm			8.45796	
Th cond Btu/hr-ft-F			0.755362E-01	
Visc cp			0.146894	
- - Vapor only - -				
lb/hr	0.773233E+07	0.588931E+07	0.567926E+07	0.184302E+07
Std Vap ft3/hr	0.101323E+09	0.794776E+08	0.766641E+08	0.218454E+08
Actual ft3/hr	0.100665E+08	0.920988E+07	0.149673E+08	0.293769E+07
lb/ft3	0.768123	0.639456	0.379445	0.627372
Cp/Cv	1.42069	1.39932	1.38240	1.41844
Compress. factor	0.994430	0.922840	0.949152	0.940645
Th cond Btu/hr-ft-F	0.155731E-01	0.472026E-02	0.441790E-02	0.477690E-02
Visc cp	0.181834E-01	0.603960E-02	0.559179E-02	0.761262E-02

STREAM PROPERTIES

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Stream No.	22	23	24	26
Name			FUEL	
Phase	Vapor	Liquid	Liquid	Vapor
From Eqp #	16	17	Feed	13
To Eqp #	3	11	17	Product
lbmol/hr	267006.	45591.4	45591.4	45591.4
Temp R	236.292	200.910	200.893	781.625
Pres psia	148.000	18.0000	14.7000	50.0000
Enth MMBtu/hr	1748.30	137.721	137.702	527.627
Cp Vap Btu/lb-R	0.280985			0.634506
Cp Liq Btu/lb-R		0.816978	0.817044	
Mol Fraction Vapor	1.00000	0.000000E+00	0.100000E-05	1.00000
Average Mol Wt	28.9594	16.0420	16.0420	16.0420
- - Liquid only - -				
lb/hr		731378.	731377.	
Std Liq gal/min		4873.26	4873.26	
Sp Gr		0.299764	0.299764	
Actual gal/min		3449.68	3449.56	
lb/gal		3.53327	3.53339	
Sf tens dyne/cm		13.6394	13.6412	
Th cond Btu/hr-ft-F		0.108775	0.108783	
Visc cp		0.119995	0.120021	
- - Vapor only - -				
lb/hr	0.773233E+07			731378.
Std Vap ft3/hr	0.101323E+09			0.173010E+08
Actual ft3/hr	0.406076E+07			0.763481E+07
lb/ft3	1.90416			0.957952E-01
Cp/Cv	1.50570			1.24735
Compress. factor	0.887767			0.998359
Th cond Btu/hr-ft-F	0.193746E-01			0.322371E-01
Visc cp	0.955926E-02			0.151287E-01

Stream No.	27	28	29	30
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	2	15	14	12
To Eqp #	21	4	15	18
lbmol/hr	293231.	293231.	175939.	117293.
Temp R	835.111	172.334	165.100	290.000
Pres psia	424.000	54.0000	54.0000	420.000
Enth MMBtu/hr	3191.79	1811.61	1076.71	796.905
Cp Vap Btu/lb-R	0.255710	0.282980	0.286954	0.328871
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.0130	28.0130	28.0130	28.0130
- - Vapor only - -				
lb/hr	0.821429E+07	0.821429E+07	0.492857E+07	0.328572E+07
Std Vap ft3/hr	0.111275E+09	0.111275E+09	0.667650E+08	0.445100E+08
Actual ft3/hr	0.625068E+07	0.911519E+07	0.517143E+07	730109.
lb/ft3	1.31414	0.901165	0.953038	4.50031
Cp/Cv	1.41512	1.42499	1.42562	1.66993
Compress. factor	1.00865	0.907776	0.895977	0.840174
Th cond Btu/hr-ft-F	0.215209E-01	0.524292E-02	0.502696E-02	0.179775E-01
Visc cp	0.249430E-01	0.672976E-02	0.646490E-02	0.118908E-01

STREAM PROPERTIES

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Stream No.	31	32	33	34
Name				
Phase	Vapor	Vapor	Mixed	Vapor
From Eqp #	18	2	22	18
To Eqp #	6	Product	3	19
lbmol/hr	293231.	209439.	117293.	45591.4
Temp R	233.997	930.360	163.438	234.151
Pres psia	51.0000	17.0000	55.0000	15.0000
Enth MMBtu/hr	1950.56	2425.89	639.868	310.601
Cp Vap Btu/lb-R	0.265200	0.252639	0.288743	0.492878
Cp Liq Btu/lb-R			0.835641	
Mol Fraction Vapor	1.00000	1.00000	0.703628	1.00000
Average Mol Wt	28.0130	28.1194	28.0130	16.0420
- - Liquid only - -				
lb/hr			973796.	
Std Liq gal/min			2408.81	
Sp Gr			0.807463	
Actual gal/min			2628.99	
lb/gal			6.17296	
Sf tens dyne/cm			5.94871	
Th cond Btu/hr-ft-F			0.650773E-01	
Visc cp			0.109590	
- - Vapor only - -				
lb/hr	0.821429E+07	0.588931E+07	0.231192E+07	731378.
Std Vap ft3/hr	0.111275E+09	0.794776E+08	0.313185E+08	0.173010E+08
Actual ft3/hr	0.139048E+08	0.123033E+09	0.234410E+07	0.746063E+07
lb/ft3	0.590752	0.478678E-01	0.986270	0.980316E-01
Cp/Cv	1.41660	1.38913	1.42715	1.34945
Compress. factor	0.963195	1.00037	0.890789	0.976986
Th cond Btu/hr-ft-F	0.225189E-01	0.230729E-01	0.497708E-02	0.741923E-02
Visc cp	0.891022E-02	0.267375E-01	0.640853E-02	0.529677E-02

STREAM PROPERTIES

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Stream No.	35	36	37	38
Name		LO2		
Phase	Liquid	Liquid	Vapor	Vapor
From Eqp #	22	23	18	19
To Eqp #	23	Product	11	6
lbmol/hr	57567.0	57567.0	117293.	45591.4
Temp R	174.511	175.206	230.000	234.151
Pres psia	35.0000	150.000	419.000	15.0000
Enth MMBtu/hr	196.261	196.879	716.867	310.601
Cp Vap Btu/lb-R			0.617032	0.492878
Cp Liq Btu/lb-R	0.402174	0.394665		
Mol Fraction Vapor	0.000000E+00	0.000000E+00	1.00000	1.00000
Average Mol Wt	32.0152	32.0152	28.0130	16.0420
- - Liquid only - -				
lb/hr	0.184302E+07	0.184302E+07		
Std Liq gal/min	3559.07	3559.07		
Sp Gr	1.03431	1.03431		
Actual gal/min	3438.01	3444.91		
lb/gal	8.93381	8.91593		
Sf tens dyne/cm	10.4241	10.3327		
Th cond Btu/hr-ft-F	0.771499E-01	0.768650E-01		
Visc cp	0.161803	0.160612		
- - Vapor only - -				
lb/hr			0.328572E+07	731378.
Std Vap ft3/hr			0.445100E+08	0.173010E+08
Actual ft3/hr			415392.	0.746063E+07
lb/ft3			7.90991	0.980316E-01
Cp/Cv			2.74043	1.34945
Compress. factor			0.601277	0.976986
Th cond Btu/hr-ft-F			0.271823E-01	0.741923E-02
Visc cp			0.112068E-01	0.529677E-02

STREAM PROPERTIES

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CHEMCAD 2 - Version 2.5

Stream No.	39	40	41	42
Name				
Phase	Liquid	Vapor	Vapor	Vapor
From Eqp #	20	21	21	20
To Eqp #	21	Product	20	6
lbmol/hr	16648.2	16648.2	293231.	293232.
Temp R	677.680	817.000	687.683	650.850
Pres psia	17.0000	16.0000	423.000	422.000
Enth MMBtu/hr	-117.827	191.948	2882.01	2804.34
Cp Vap Btu/lb-R		0.471307	0.256552	0.257206
Cp Liq Btu/lb-R	1.00411			
Mol Fraction Vapor	0.000000E+00	1.00000	1.00000	1.00000
Average Mol Wt	18.0200	18.0200	28.0130	28.0130
- - Liquid only - -				
lb/hr	300000.			
Std Liq gal/min	599.680			
Sp Gr	0.999212			
Actual gal/min	655.785			
lb/gal	7.62383			
Sf tens dyne/cm	57.9759			
Th cond Btu/hr-ft-F	0.394365			
Visc cp	0.269482			
- - Vapor only - -				
lb/hr		300000.	0.821429E+07	0.821430E+07
Std Vap ft3/hr		0.631762E+07	0.111275E+09	0.111275E+09
Actual ft3/hr		0.907163E+07	0.513625E+07	0.486237E+07
lb/ft3		0.330701E-01	1.59928	1.68936
Cp/Cv		1.33418	1.43238	1.43690
Compress. factor		0.994528	1.00413	1.00200
Th cond Btu/hr-ft-F		0.182411E-01	0.187169E-01	0.180392E-01
Visc cp		0.153818E-01	0.217656E-01	0.209308E-01

Stream No.	43
Name	
Phase	Liquid
From Eqp #	25
To Eqp #	20
lbmol/hr	16648.2
Temp R	420.075
Pres psia	20.0000
Enth MMBtu/hr	-195.482
Cp Liq Btu/lb-R	1.00475
Mol Fraction Vapor	0.000000E+00
Average Mol Wt	18.0200
- - Liquid only - -	
lb/hr	300000.
Std Liq gal/min	599.680
Sp Gr	0.999212
Actual gal/min	566.568
lb/gal	8.82436
Sf tens dyne/cm	83.2370
Th cond Btu/hr-ft-F	0.277922
Visc cp	6.65215

FLOW SUMMARIES

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CHEMCAD 2 - Version 2.5

Stream No. Name	1	2	4	5
Temp R	1120.36	290.000	183.523	194.876
Pres psia	425.000	420.000	54.0000	147.000
Enth MMBtu/hr	3795.06	1992.26	734.897	1653.27
Vapor mole fraction	1.00000	1.00000	1.00000	0.999990
Total lbmol/hr	293231.	293231.	117293.	267006.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.000000	0.781201
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.209459
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.934058E-02
Methane	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	6	7	8	9
Temp R	163.438	202.915	563.271	177.334
Pres psia	55.0000	52.0000	49.0000	416.000
Enth MMBtu/hr	481.037	1881.79	2639.34	485.072
Vapor mole fraction	0.854528E-01	1.00000	1.00000	0.000000E+00
Total lbmol/hr	117293.	293231.	293231.	117293.
Component mole fractions				
Nitrogen	1.000000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methane	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	10	11	12	13
Temp R	563.175	290.000	156.046	563.271
Pres psia	13.0000	420.000	35.0000	49.0000
Enth MMBtu/hr	433.912	1195.36	1273.53	2639.34
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	45591.4	175939.	209439.	293231.
Component mole fractions				
Nitrogen	0.000000E+00	1.00000	0.973297	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.267035E-01	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methane	1.00000	0.000000E+00	0.000000E+00	0.000000E+00
Stream No. Name	14	15	16	17
Temp R	210.169	420.000	203.267	WN2 520.000
Pres psia	418.000	14.6960	16.0000	18.0000
Enth MMBtu/hr	555.249	-195.487	299.339	1822.62
Vapor mole fraction	0.000000E+00	0.000000E+00	1.00000	1.00000
Total lbmol/hr	117293.	16648.2	45591.4	209439.
Component mole fractions				
Nitrogen	1.00000	0.000000E+00	0.000000E+00	0.973296
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.267035E-01
Water	0.000000E+00	1.00000	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methane	0.000000E+00	0.000000E+00	1.00000	0.000000E+00

FLOW SUMMARIES

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CHEMCAD 2 - Version 2.5

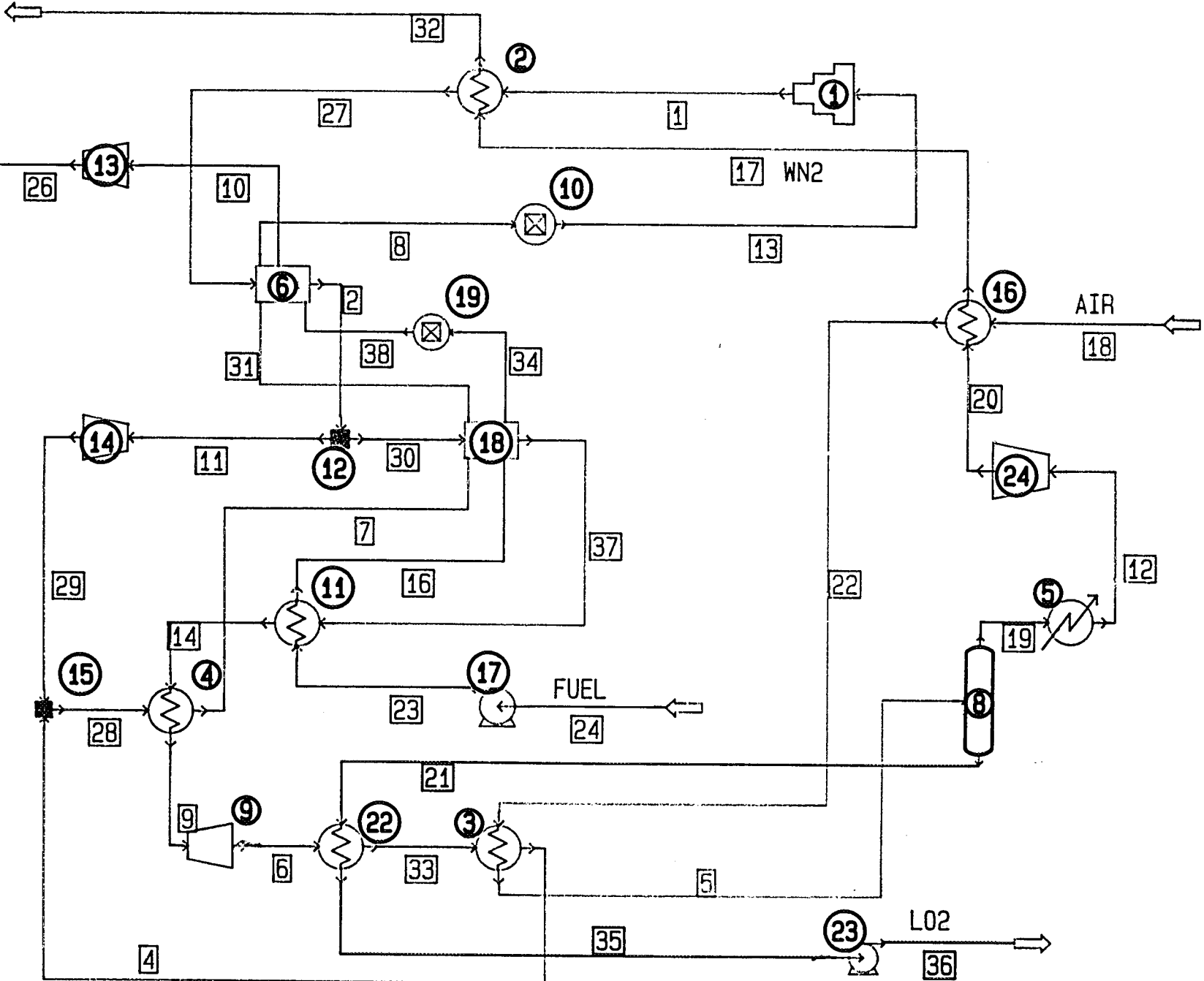
Stream No.	18	19	20	21
Name	AIR			
Temp R	530.000	155.431	145.490	176.960
Pres psia	150.000	35.0000	20.0000	35.0000
Enth MMBtu/hr	2326.32	1272.53	1244.60	355.092
Vapor mole fraction	1.00000	1.00000	0.964600	1.00000
Total lbmol/hr	267006.	209439.	209439.	57567.0
Component mole fractions				
Nitrogen	0.781201	0.973297	0.973296	0.823215E-01
Oxygen	0.209459	0.267035E-01	0.267035E-01	0.874355
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.934058E-02	0.000000E+00	0.000000E+00	0.433233E-01
Methane	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	22	23	24	26
Name			FUEL	
Temp R	236.292	200.910	200.893	781.625
Pres psia	148.000	18.0000	14.7000	50.0000
Enth MMBtu/hr	1748.30	137.721	137.702	527.627
Vapor mole fraction	1.00000	0.000000E+00	0.100000E-05	1.00000
Total lbmol/hr	267006.	45591.4	45591.4	45591.4
Component mole fractions				
Nitrogen	0.781201	0.000000E+00	0.000000E+00	0.000000E+00
Oxygen	0.209459	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.934058E-02	0.000000E+00	0.000000E+00	0.000000E+00
Methane	0.000000E+00	1.00000	1.00000	1.00000
Stream No.	27	28	29	30
Name				
Temp R	835.111	172.334	165.100	290.000
Pres psia	424.000	54.0000	54.0000	420.000
Enth MMBtu/hr	3191.79	1811.61	1076.71	796.905
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	293231.	293231.	175939.	117293.
Component mole fractions				
Nitrogen	1.00000	1.00000	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methane	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	31	32	33	34
Name				
Temp R	233.997	930.360	163.438	234.151
Pres psia	51.0000	17.0000	55.0000	15.0000
Enth MMBtu/hr	1950.56	2425.89	639.868	310.601
Vapor mole fraction	1.00000	1.00000	0.703628	1.00000
Total lbmol/hr	293231.	209439.	117293.	45591.4
Component mole fractions				
Nitrogen	1.00000	0.973296	1.000000	0.000000E+00
Oxygen	0.000000E+00	0.267035E-01	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methane	0.000000E+00	0.000000E+00	0.000000E+00	1.00000

FLOW SUMMARIES

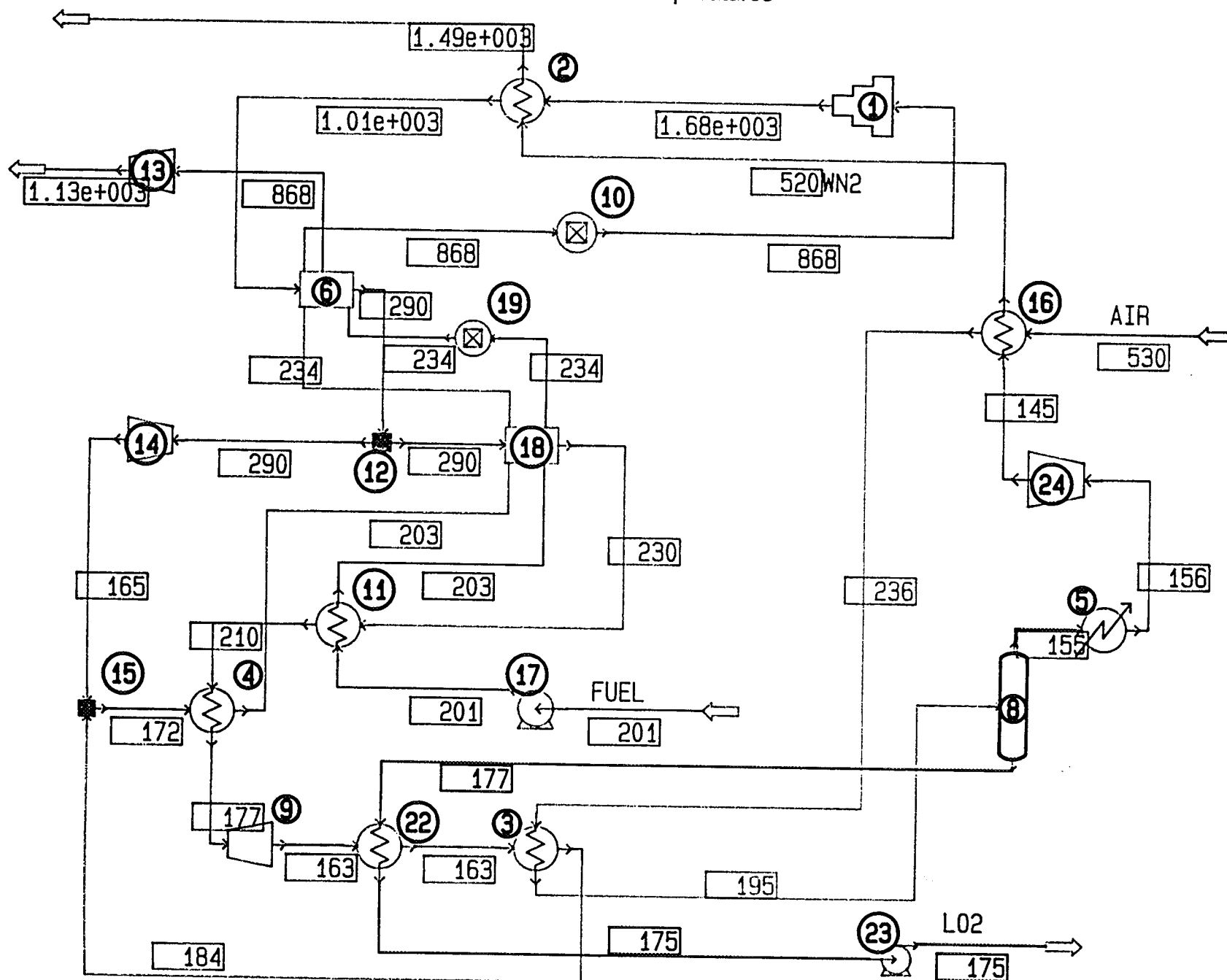
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Stream No.	35	36	37	38
Name		LO2		
Temp R	174.511	175.206	230.000	234.151
Pres psia	35.0000	150.000	419.000	15.0000
Enth MMBtu/hr	196.261	196.879	716.867	310.601
Vapor mole fraction	0.000000E+00	0.000000E+00	1.00000	1.00000
Total lbmol/hr	57567.0	57567.0	117293.	45591.4
Component mole fractions				
Nitrogen	0.823215E-01	0.823215E-01	1.00000	0.000000E+00
Oxygen	0.874355	0.874355	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Argon	0.433233E-01	0.433233E-01	0.000000E+00	0.000000E+00
Methane	0.000000E+00	0.000000E+00	0.000000E+00	1.00000
Stream No.	39	40	41	42
Name				
Temp R	677.680	817.000	687.683	650.850
Pres psia	17.0000	16.0000	423.000	422.000
Enth MMBtu/hr	-117.827	191.948	2882.01	2804.34
Vapor mole fraction	0.000000E+00	1.00000	1.00000	1.00000
Total lbmol/hr	16648.2	16648.2	293231.	293232.
Component mole fractions				
Nitrogen	0.000000E+00	0.000000E+00	1.00000	1.00000
Oxygen	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	1.00000	1.00000	0.000000E+00	0.000000E+00
Argon	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Methane	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	43			
Name				
Temp R	420.075			
Pres psia	20.0000			
Enth MMBtu/hr	-195.482			
Vapor mole fraction	0.000000E+00			
Total lbmol/hr	16648.2			
Component mole fractions				
Nitrogen	0.000000E+00			
Oxygen	0.000000E+00			
Water	1.00000			
Argon	0.000000E+00			
Methane	0.000000E+00			

Case 5



Case 5
LIQUID METHANE NO WATER CYCLE
Stream Temperatures



Job Name: LIN500M2

Date: 10/14/92 Time: 09:03:31

SINGLE COMPRESSOR AND THREE EXPANDERS

FLOWSHEET SUMMARY

Equipment	Label	Stream Numbers
1	COMP	13 -1
2	HTXR	1 17 -27 -32
3	HTXR	33 22 -4 -5
4	HTXR	28 14 -7 -9
5	HTXR	19 -12
6	LNGH	27 31 38 -2 -8 -10
8	CSEP	5 -19 -21
9	EXPN	9 -6
10	CONT	8 -13
11	HTXR	37 23 -14 -16
12	DIVI	2 -11 -30
13	COMP	10 -26
14	EXPN	11 -29
15	MIXE	29 4 -28
16	HTXR	18 20 -22 -17
17	PUMP	24 -23
18	LNGH	30 7 16 -37 -31 -34
19	CONT	34 -38
22	HTXR	6 21 -33 -35
23	PUMP	35 -36
24	EXPN	12 -20

Stream Connections

Stream	Equipment		Stream	Equipment		Stream	Equipment	
	From	To		From	To		From	To
1	1	2	14	11	4	28	15	4
2	6	12	16	11	18	29	14	15
4	3	15	17	16	2	30	12	18
5	3	8	18		16	31	18	6
6	9	22	19	8	5	32	2	
7	4	18	20	24	16	33	22	3
8	6	10	21	8	22	34	18	19
9	4	9	22	16	3	35	22	23
10	6	13	23	17	11	36	23	
11	12	14	24		17	37	18	11
12	5	24	26	13		38	19	6
13	10	1	27	2	6			

Equipment Calculation Sequence

17 12 14 15 4 9 22 18 19 11 3 8 5 24 16 2 6 10
1 13 23

Recycle calculation has converged.

Equipment Recycle Sequence

12 14 15 4 9 22 18 19 11 3 8 5 24 16 2 6 10 1

Recycle Cut Streams

2 1 4 16 21 22 14

Recycle Convergence Method: DEM

DEM damping factor 0.70
Acceleration frequency 4
Max. loop iterations 40

Recycle Convergence Tolerance

Flow rate 1.000E-003
Temperature 1.000E-003
Pressure 1.000E-003
Enthalpy 1.000E-003
Vapor frac. 1.000E-003

COMPONENTS

	ID #	Name
1	46	Nitrogen
2	47	Oxygen
3	62	Water
4	98	Argon
5	2	Methane

THERMODYNAMICS

K-value model : Peng-Robinson
Enthalpy model : Peng-Robinson
Liquid density : API

Overall Mass Balance	lbmol/hr		lb/hr	
	Input	Output	Input	Output
Nitrogen	208585.297	208585.297	5843100.000	5843100.000
Oxygen	55926.746	55926.746	1789600.000	1789600.000
Water	0.000	0.000	0.000	0.000
Argon	2493.992	2493.992	99630.008	99630.008
Methane	45591.449	45591.449	731378.000	731378.000
Total	312597.469	312597.469	8463708.000	8463708.000

EQUIPMENT SUMMARIES

Compressor Summary

Equip. No.	1	13
Name		
Mode	0	0
P out or ratio psia	425.0000	50.0000
Type	0	0
Efficiency	0.8500	0.8500
Actual work HP	693494.5625	55239.6172
Cp/Cv	1.3945	1.2279
Theoretical work HP	589470.3750	46953.6797

Heat Exchanger Summary

Equip. No.	2	3	4	5
Name				
Pressure drop psia	1.0000	1.0000	2.0000	
Pressure drop psia	1.0000	1.0000	2.0000	
2nd Vout		1.0000		
Min. delta T R	190.0000		5.0000	
Heat duty MMBtu/hr				1
U Btu/ft2/R/hr	20.0000	20.0000	100.0000	
Calc heat duty (MMBtu/hr)	1.46E+003	95	69.6	1
LMTD R	317.9739	41.1963	6.1508	
LMTD Corr.factr	1.0000	1.0000	1.0000	
Calculated A ft2	230246.2813	115355.8906	113081.9922	
	$H = 50$ $A = 92,098$	$H = 50$ $A = 46,142$		
Equip. No.	11	16	22	
Name				
Pressure drop psia	1.0000	2.0000		
Pressure drop psia	2.0000	2.0000		
2nd subcooled R			0.0100	
2nd superheated R	0.5000			
Min. delta T R		10.0000		
U Btu/ft2/R/hr	50.0000	20.0000	1400.0000	
Calc heat duty (MMBtu/hr)	162	578	159	
LMTD R	16.3566	36.6268	12.2572	
LMTD Corr.factr	1.0000	1.0000	1.0000	
Calculated A ft2	197618.2656	789044.1875	9255.8340	
	$U = 100$ $A = 98,809$	$U = 50$ $A = 315,617$		

EQUIPMENT SUMMARIES

LNGH Summary

Equip. No.	6	18
Name		
1st strm P drop psia	2.0000	1.0000
1st strm mode	1	1
1st strm spec	290.0000	230.0000
2nd strm P drop psia	2.0000	1.0000
2nd strm mode	1	1
2nd strm spec	868.3958	233.8280
3rd strm P drop psia	2.0000	1.0000
Overall Q MMBtu/hr	1.58E+003	80.4
Q1 MMBtu/hr	-1.58E+003	-80.4
Q2 MMBtu/hr	1.32E+003	69.3
Q3 MMBtu/hr	259	11.1
Q4 MMBtu/hr	70.3	
ΔT_{MD}	93.9	40.2
U	20	20
Area	341,300	100,000

Component Separator Summary

Equip. No.	8
Name	
Pout or P drop psia	35.0000
T mode top	2
T mode bottom	2
Split mode	1
Split destination	1
Frac/flow comp 1	4739.0000
Frac/flow comp 2	50334.0000
Frac/flow comp 4	2494.0000

Expander Summary

Equip. No.	9	14	24
Name			
Mode	0	0	0
P out or ratio psia	55.0000	54.0000	20.0000
Type	0	0	0
Efficiency	0.8000	0.9000	0.9000
Actual work HP	-1634.9684	-46600.4219	-11360.0596
Cp/Cv	2.1251	1.6719	1.3994
Theoretical work HP	-2043.7104	-51778.2461	-12622.2881

EQUIPMENT SUMMARIES

Controller Summary

Equip. No.	10	19
Name		
Mode	2	2
Equip. no. adjusted	6	18
Variable no.	7	7
Measured variables:		
Type	0	0
Str no/ Eqp no	8	34
Variable no.	1	1
Scale	1.0000	1.0000
Type	0	0
Str no/ Eqp no	10	31
Variable no.	1	1
Scale	1.0000	1.0000

Divider Summary

Equip. No.	12
Name	
Mode	0
Flow ratio/rate #1	0.6000
Flow ratio/rate #2	0.4000

Mixer Summary

Equip. No.	15
Name	
Output pressure	psia

Pump Summary

Equip. No.	17	23
Name		
Output pressure	psia	
	18.0000	150.0000
Efficiency	0.9000	0.9500
Work required	HP	
	7.3838	242.9552

FLOW SUMMARIES

Stream No.	1	2	4	5
Name				
Temp R	1681.4194	290.0000	183.5017	194.8759
Pres psia	425.0000	422.0000	54.0000	147.0000
Enth MMBtu/hr	5032.	1992.	734.9	1653.
Vapor mole fraction	1.000	1.000	1.000	1.000
Total lbmol/hr	293231.500	293231.313	117292.516	267006.031
Flowrates in lbmol/hr				
Nitrogen	293231.500	293231.313	117292.523	208585.297
Oxygen	0.000	0.000	0.000	55926.746
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	2493.992
Methane	0.000	0.000	0.000	0.000
Stream No.	6	7	8	9
Name				
Temp R	163.4376	202.5352	868.3958	177.3788
Pres psia	55.0000	52.0000	49.0000	418.0000
Enth MMBtu/hr	481.0	1881.	3267.	485.2
Vapor mole fraction	0.08524	1.000	1.000	0.0000
Total lbmol/hr	117292.516	293231.500	293231.500	117292.523
Flowrates in lbmol/hr				
Nitrogen	117292.523	293231.500	293231.500	117292.523
Oxygen	0.000	0.000	0.000	0.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	0.000
Methane	0.000	0.000	0.000	0.000
Stream No.	10	11	12	13
Name				
Temp R	867.9310	290.0000	156.0456	868.3958
Pres psia	13.0000	422.0000	35.0000	49.0000
Enth MMBtu/hr	569.2	1195.	1274.	3267.
Vapor mole fraction	1.000	1.000	1.000	1.000
Total lbmol/hr	45591.449	175938.906	209439.047	293231.500
Flowrates in lbmol/hr				
Nitrogen	0.000	175938.906	203846.297	293231.500
Oxygen	0.000	0.000	5592.746	0.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	0.000
Methane	45591.449	0.000	0.000	0.000
Stream No.	14	16	17	18
Name				
Temp R	210.0011	203.2667	520.0000	530.0000
Pres psia	420.0000	16.0000	18.0000	150.0000
Enth MMBtu/hr	554.7	299.3	1823.	2326.
Vapor mole fraction	0.0000	1.000	1.000	1.000
Total lbmol/hr	117292.602	45591.449	209439.063	267006.031
Flowrates in lbmol/hr				
Nitrogen	117292.602	0.000	203846.297	208585.297
Oxygen	0.000	0.000	5592.747	55926.746
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	2493.992
Methane	0.000	45591.449	0.000	0.000

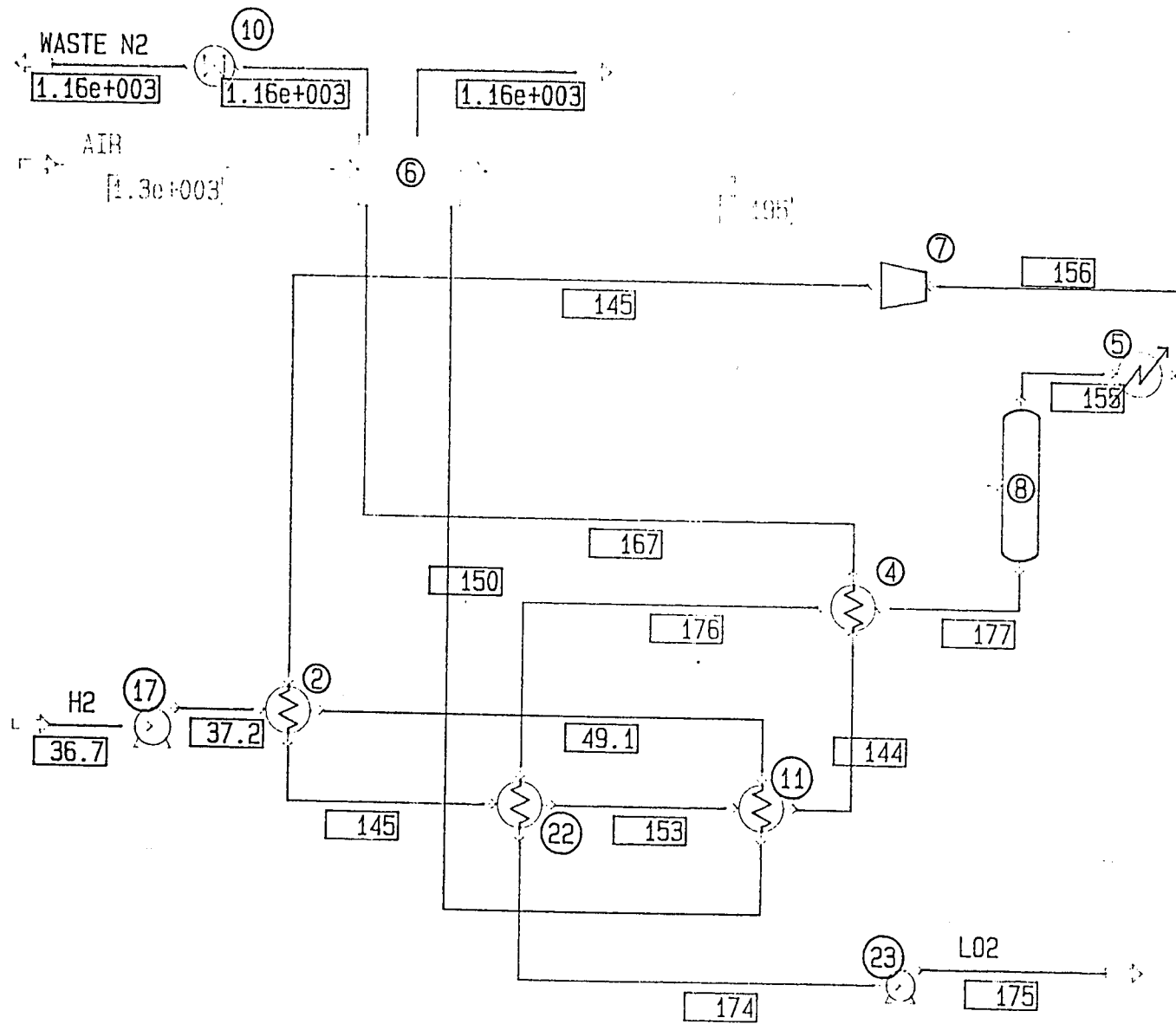
FLOW SUMMARIES

Stream No.	19	20	21	22
Name				
Temp R	155.4313	145.4899	176.9598	236.2922
Pres psia	35.0000	20.0000	35.0000	148.0000
Enth MMBtu/hr	1273.	1245.	355.1	1748.
Vapor mole fraction	1.000	0.9646	1.000	1.000
Total lbmol/hr	209439.047	209439.063	57566.992	267006.031
Flowrates in lbmol/hr				
Nitrogen	203846.297	203846.297	4739.000	208585.297
Oxygen	5592.746	5592.747	50334.000	55926.746
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	2493.992	2493.992
Methane	0.000	0.000	0.000	0.000
Stream No.	23	24	26	27
Name		FUEL		
Temp R	200.9096	200.8926	1131.2312	1013.5160
Pres psia	18.0000	14.7000	50.0000	424.0000
Enth MMBtu/hr	137.7	137.7	709.8	3568.
Vapor mole fraction	0.0000	1.000E-006	1.000	1.000
Total lbmol/hr	45591.449	45591.449	45591.449	293231.313
Flowrates in lbmol/hr				
Nitrogen	0.000	0.000	0.000	293231.313
Oxygen	0.000	0.000	0.000	0.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	0.000
Methane	45591.449	45591.449	45591.449	0.000
Stream No.	28	29	30	31
Name				
Temp R	172.3788	164.9654	290.0000	233.8280
Pres psia	54.0000	54.0000	422.0000	51.0000
Enth MMBtu/hr	1811.	1077.	796.7	1950.
Vapor mole fraction	1.000	1.000	1.000	1.000
Total lbmol/hr	293231.500	175938.906	117292.602	293231.500
Flowrates in lbmol/hr				
Nitrogen	293231.500	175938.906	117292.602	293231.500
Oxygen	0.000	0.000	0.000	0.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	0.000
Methane	0.000	0.000	0.000	0.000
Stream No.	32	33	34	35
Name				
Temp R	1491.4194	163.4375	233.8448	174.5111
Pres psia	17.0000	55.0000	15.0000	35.0000
Enth MMBtu/hr	3287.	639.8	310.5	196.3
Vapor mole fraction	1.000	0.7034	1.000	0.0000
Total lbmol/hr	209439.063	117292.516	45591.449	57566.992
Flowrates in lbmol/hr				
Nitrogen	203846.297	117292.523	0.000	4739.000
Oxygen	5592.747	0.000	0.000	50334.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	2493.992
Methane	0.000	0.000	45591.449	0.000

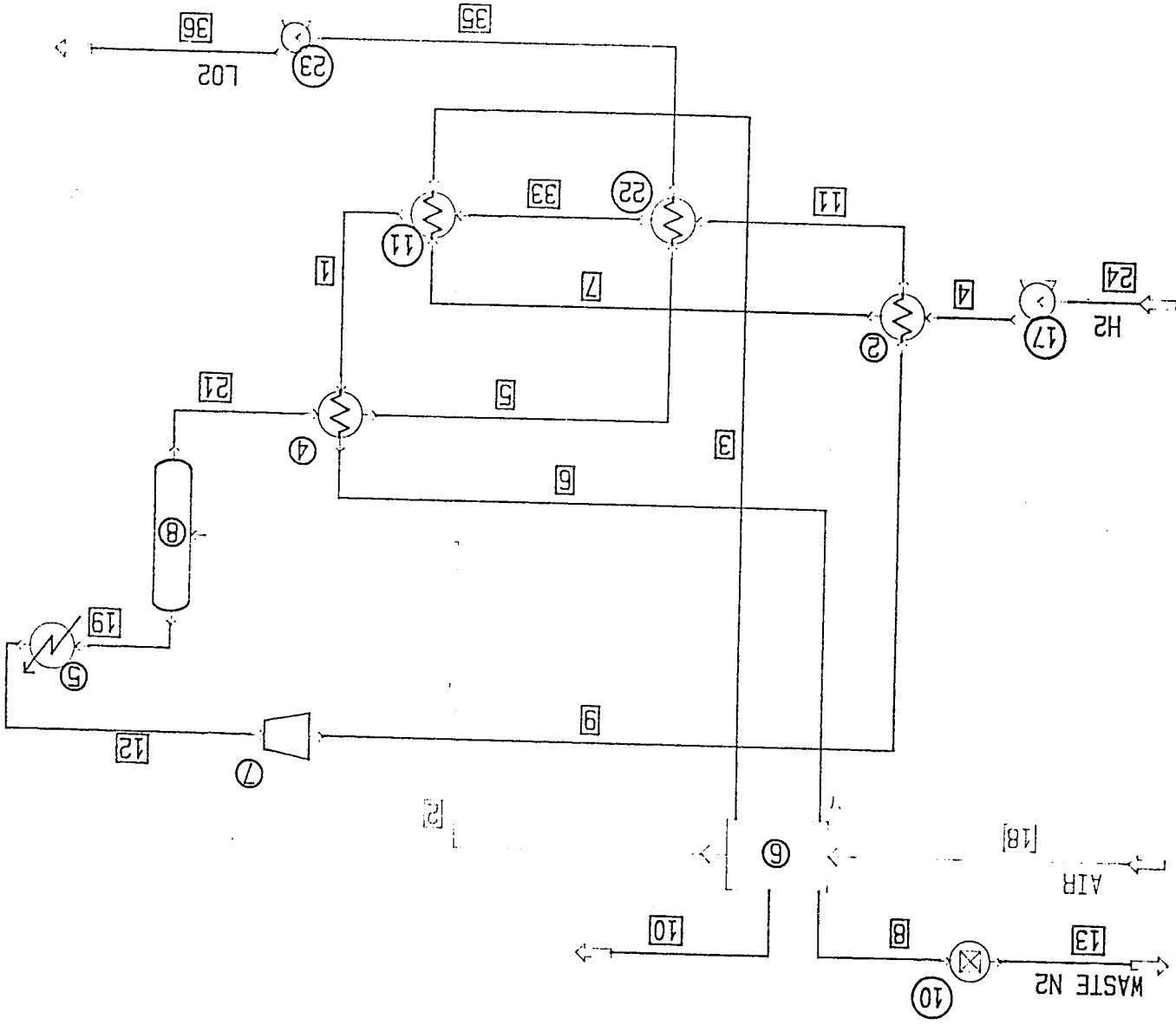
FLOW SUMMARIES

Stream No.		36	37	38
Name	LO2			
Temp R		175.2063	230.0000	233.8448
Pres psia		150.0000	421.0000	15.0000
Enth MMBtu/hr		196.9	716.3	310.5
Vapor mole fraction		0.0000	1.000	1.000
Total lbmol/hr		57566.992	117292.602	45591.449
Flowrates in lbmol/hr				
Nitrogen		4739.000	117292.602	0.000
Oxygen		50334.000	0.000	0.000
Water		0.000	0.000	0.000
Argon		2493.992	0.000	0.000
Methane		0.000	0.000	45591.449

Case 6
LIQUID HYDROGEN CYCLE
Stream Temperatures



Case 6
LIQUID HYDROGEN CYCLE
Stream and Equipment Numbers



Case 6
LIQUID HYDROGEN CYCLE
Stream Properties

CHEMCAD II Version 2.6

Page 1

Job Name: LIN500H

Date: 10/14/92 Time: 09:01:37

SINGLE COMPRESSOR AND THREE EXPANDERS

FLOWSHEET SUMMARY

Equipment	Label	Stream Numbers
2	HTXR	4 9 -7 -11
4	HTXR	21 1 -5 -6
5	HTXR	19 -12
6	LNGH	18 6 3 -2 -8 -10
7	EXPN	12 -9
8	CSEP	2 -19 -21
10	CONT	8 -13
11	HTXR	33 7 -1 -3
17	PUMP	24 -4
22	HTXR	11 5 -33 -35
23	PUMP	35 -36

Stream Connections

Stream	Equipment		Stream	Equipment		Stream	Equipment	
	From	To		From	To		From	To
1	11	4	8	6	10	19	8	5
2	6	8	9	7	2	21	8	4
3	11	6	10	6		24		17
4	17	2	11	2	22	33	22	11
5	4	22	12	5	7	35	22	23
6	4	6	13	10		36	23	
7	2	11	18		6			

Equipment Calculation Sequence

17 8 5 7 2 22 11 4 6 10 23

Recycle calculation has converged.

Equipment Recycle Sequence

8 5 7 2 22 11 4 6

Recycle Cut Streams

2 5

Recycle Convergence Method: DEM

DEM damping factor 0.70
Acceleration frequency 4
Max. loop iterations 40

Recycle Convergence Tolerance

Flow rate 1.000E-003
Temperature 1.000E-003
Pressure 1.000E-003
Enthalpy 1.000E-003
Vapor frac. 1.000E-003

COMPONENTS

	ID #	Name
1	46	Nitrogen
2	47	Oxygen
3	62	Water
4	98	Argon
5	2	Methane
6	1	Hydrogen

THERMODYNAMICS

K-value model : Peng-Robinson
Water/Hydrocarbon immiscible
Enthalpy model : Peng-Robinson
Liquid density : API

Overall Mass Balance	lbmol/hr		lb/hr	
	Input	Output	Input	Output
Nitrogen	208590.000	208590.000	5843232.000	5843232.000
Oxygen	55927.000	55927.000	1789608.125	1789608.125
Water	0.000	0.000	0.000	0.000
Argon	2494.000	2494.000	99630.320	99630.320
Methane	0.000	0.000	0.000	0.000
Hydrogen	100670.000	100670.000	202950.719	202950.719
Total	367681.000	367681.000	7935421.000	7935421.000

EQUIPMENT SUMMARIES

Heat Exchanger Summary

Equip. No.	2	4	5	11
Name				
Pressure drop psia	1.0000	1.0000		1.0000
Pressure drop psia	1.0000	1.0000		2.0000
1st Vout	1.0000			
Min. delta T R		10.0000		3.0000
Heat duty MMBtu/hr			1	
U Btu/ft ² /R/hr	1400.0000	20.0000		20.0000
Calc heat duty (MMBtu/hr)	42.9	88.4	1	65.5
LMTD R	101.7730	18.8793		26.5314
LMTD Corr.factr	1.0000	1.0000		1.0000
Calculated A ft ²	301.2927	234009.9375		123390.2266
		<i>H = 50</i>		<i>H = 50</i>
Equip. No.	22	<i>A = 93,603</i>		<i>A = 49,356</i>
Name				
2nd subcooled R	0.0100			
U Btu/ft ² /R/hr	1400.0000			
Calc heat duty (MMBtu/hr)	70.9			
LMTD R	25.9730			
LMTD Corr.factr	1.0000			
Calculated A ft ²	1949.9258			

LNGH Summary

Equip. No.	6
Name	
1st strm P drop psia	2.0000
1st strm mode	2
1st strm spec	1.0000
2nd strm P drop psia	2.0000
2nd strm mode	1
2nd strm spec	1161.2249
3rd strm P drop psia	2.0000
Overall Q MMBtu/hr	2.16E+003
Q1 MMBtu/hr	-2.16E+003
Q2 MMBtu/hr	1.48E+003
Q3 MMBtu/hr	679
Q4 MMBtu/hr	70.3
<i>LMTD = 69.3 °F</i>	
<i>U = 20 Btu/hr ft² °F</i>	
<i>Area = 1.56 × 10⁶ ft²</i>	

EQUIPMENT SUMMARIES

Expander Summary

Equip. No.	7
Name	
Mode	0
P out or ratio psia	20.0000
Type	0
Efficiency	0.8500
Actual work HP	-10726.7607
Cp/Cv	1.3995
Theoretical work HP	-12619.7178

Component Separator Summary

Equip. No.	8
Name	
Pout or P drop psia	35.0000
T mode top	2
T mode bottom	2
Split mode	1
Split destination	1
Frac/flow comp 1	4739.0000
Frac/flow comp 2	50334.0000
Frac/flow comp 4	2494.0000

Controller Summary

Equip. No.	10
Name	
Mode	2
Equip. no. adjusted	6
Variable no.	7
Measured variables:	
Type	0
Str no/ Eqp no	8
Variable no.	1
Scale	1.0000
Type	0
Str no/ Eqp no	10
Variable no.	1
Scale	1.0000

EQUIPMENT SUMMARIES

Pump Summary

Equip. No.	17	23
Name		
Output pressure psia	75.0000	150.0000
Efficiency	0.8000	0.9500
Work required HP	253.1902	244.6361

FLOW SUMMARIES

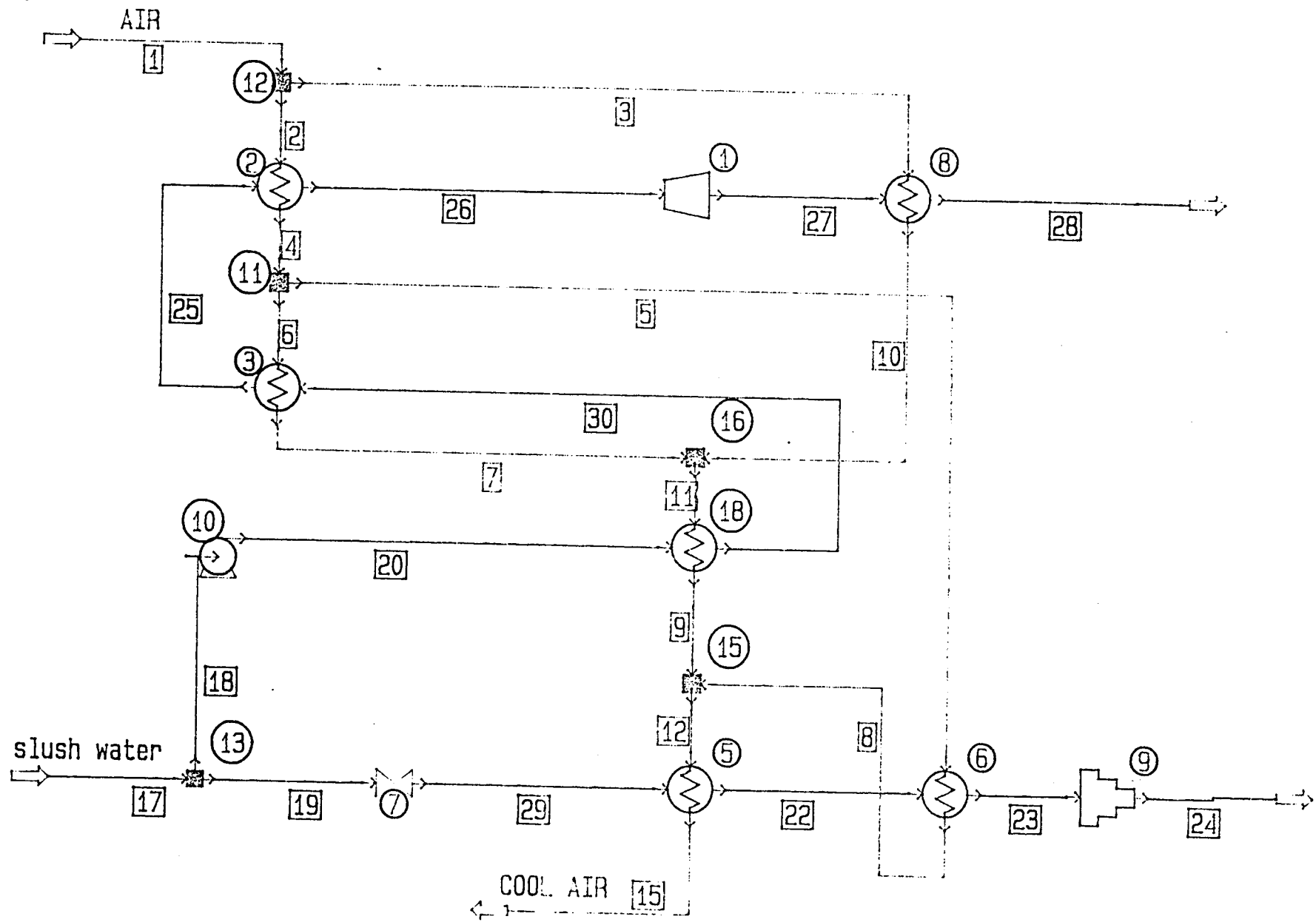
Stream No.	1	2	3	4
Name				
Temp R	143.6531	195.0637	149.7202	37.1550
Pres psia	18.0000	148.0000	72.0000	75.0000
Enth MMBtu/hr	1209.	1653.	592.3	483.9
Vapor mole fraction	0.8981	1.000	1.000	0.0000
Total lbmol/hr	209444.000	267011.000	100670.000	100670.000
Flowrates in lbmol/hr				
Nitrogen	203851.000	208590.000	0.000	0.000
Oxygen	5593.000	55927.000	0.000	0.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	2494.000	0.000	0.000
Methane	0.000	0.000	0.000	0.000
Hydrogen	0.000	0.000	100670.000	100670.000
Stream No.	5	6	7	8
Name				
Temp R	175.5540	166.9598	49.1073	1161.2249
Pres psia	34.0000	17.0000	74.0000	15.0000
Enth MMBtu/hr	266.7	1297.	526.8	2773.
Vapor mole fraction	0.4476	1.000	1.000	1.000
Total lbmol/hr	57567.000	209444.000	100670.000	209444.000
Flowrates in lbmol/hr				
Nitrogen	4739.000	203851.000	0.000	203851.000
Oxygen	50334.000	5593.000	0.000	5593.000
Water	0.000	0.000	0.000	0.000
Argon	2494.000	0.000	0.000	0.000
Methane	0.000	0.000	0.000	0.000
Hydrogen	0.000	0.000	100670.000	0.000
Stream No.	9	10	11	12
Name				
Temp R	145.4966	1160.9353	144.5086	156.0500
Pres psia	20.0000	70.0000	19.0000	35.0000
Enth MMBtu/hr	1246.	1271.	1203.	1274.
Vapor mole fraction	0.9678	1.000	0.8852	1.000
Total lbmol/hr	209444.000	100670.000	209444.000	209444.000
Flowrates in lbmol/hr				
Nitrogen	203851.000	0.000	203851.000	203851.000
Oxygen	5593.000	0.000	5593.000	5593.000
Water	0.000	0.000	0.000	0.000
Argon	0.000	0.000	0.000	0.000
Methane	0.000	0.000	0.000	0.000
Hydrogen	0.000	100670.000	0.000	0.000

FLOW SUMMARIES

Stream No.		13	18	19	21
Name		WASTE N2	AIR		
Temp R		1161.2249	1300.0000	155.4313	176.9598
Pres psia		15.0000	150.0000	35.0000	35.0000
Enth MMBtu/hr		2773.	3809.	1273.	355.1
Vapor mole fraction		1.000	1.000	1.000	1.000
Total lbmol/hr		209444.000	267011.000	209444.000	57567.000
Flowrates in lbmol/hr					
Nitrogen		203851.000	208590.000	203851.000	4739.000
Oxygen		5593.000	55927.000	5593.000	50334.000
Water		0.000	0.000	0.000	0.000
Argon		0.000	2494.000	0.000	2494.000
Methane		0.000	0.000	0.000	0.000
Hydrogen		0.000	0.000	0.000	0.000

Stream No.		24	33	35	36
Name		H2			LO2
Temp R		36.7344	152.7202	173.8962	174.5819
Pres psia		14.7000	19.0000	34.0000	150.0000
Enth MMBtu/hr		483.2	1274.	195.8	196.4
Vapor mole fraction		1.000E-006	1.000	0.0000	0.0000
Total lbmol/hr		100670.000	209444.000	57567.000	57567.000
Flowrates in lbmol/hr					
Nitrogen		0.000	203851.000	4739.000	4739.000
Oxygen		0.000	5593.000	50334.000	50334.000
Water		0.000	0.000	0.000	0.000
Argon		0.000	0.000	2494.000	2494.000
Methane		0.000	0.000	0.000	0.000
Hydrogen		100670.000	0.000	0.000	0.000

Air Cooling Cycle Stream and Equipment Numbers



CHEMCAD 2 Version 2.5

Filename : JP-BOND2.TLK

Date: 9-Apr-92 Time: 8:34 am

BILL BONDS WARM END WATER COOLING

FLowsheet Summary

Equipment	Stream Numbers
1 EXPN	26 -27
2 HTXR	25 2 -26 -4
3 HTXR	30 6 -25 -7
5 HTXR	29 12 -22 -15
6 HTXR	22 5 -23 -8
7 VALV	19 -29
8 HTXR	27 3 -28 -10
9 COMP	23 -24
10 PUMP	18 -20
11 DIVI	4 -5 -6
12 DIVI	1 -3 -2
13 DIVI	17 -18 -19
15 MIXE	9 8 -12
16 MIXE	10 7 -11
18 HTXR	20 11 -30 -9

Stream Connections

Stream	Equipment		Stream	Equipment		Stream	Equipment	
	From	To		From	To		From	To
1		12	10	8	16	23	6	9
2	12	2	11	16	18	24	9	
3	12	8	12	15	5	25	3	2
4	2	11	15	5		26	2	1
5	11	6	17		13	27	1	8
6	11	3	18	13	10	28	8	
7	3	16	19	13	7	29	7	5
8	6	15	20	10	18	30	18	3
9	18	15	22	5	6			

Recycle Sequence

11 18 3 2 1 8 16

Cut Streams

11 4 8

Accelerated Streams

11 4 8

Successive Substitution Method

Recycle calculations have converged

COMPONENTS

475 62

THERMODYNAMICS

K-value model :SRK

Enthalpy model :SRK

Liquid density :API

Water miscible

Divider Summary

Equipment name			
number	11	12	13
Mode	3	3	3
Flow rate/ratio	0.408960E+07	0.112610E+07	450000.
Flow rate/ratio	0.000000E+00	0.000000E+00	0.000000E+00

Mixer Summary

Equipment name		
number	15	16
Outlet pres. psia	150.000	150.000

Valve Summary

Equipment name	
number	7
Pres. spec psia	Pres. out 0.256300

Heat Exchanger Summary

Page 4

Equipment name	number	2	3	5	6
Delta P str 1 psia		0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Delta P str 2 psia		0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
T str 2 out F				70.0000	114.000
Min. approach temp. F		10.0000	10.0000		
Case flag		Design	Design	Design	Design
HTC Btu/ft2-hr-F		50.0000	30.0000	50.0000	50.0000
Calc. duty KBtu /hr		272279.	262985.	82492.4	570965.
Calc. LMTD F		48.5495	48.5055	71.7060	201.595
Calc. LMTD factor		1.00000	1.00000	1.00000	1.00000
Utility option flag		0	0	0	0
Calc area ft2		112166.	180725.	23008.5	56644.8
	H =	100	70	100	100
	A =	56083	77454	11505	28323

Heat Exchanger Summary

Equipment name	number	8	18
Delta P str 1 psia		0.000000E+00	0.000000E+00
Delta P str 2 psia		0.000000E+00	0.000000E+00
Min. approach temp. F			10.0000
T(hot in- cold out) F		10.0000	
Case flag		Design	Design
HTC Btu/ft2-hr-F		20.0000	30.0000
Calc. duty KBtu /hr		164063.	128609.
Calc. LMTD F		20.5349	51.6312
Calc. LMTD factor		1.00000	1.00000
Utility option flag		0	0
Calc area ft2		399473.	83030.3
	H =	50	70
	A =	159789	35584

Pump Summary

Equipment name	
number	10
Output pres. psia	1000.00
Pump efficiency	0.800000
Work required	
Kw	455.414

Compressor Summary

Equipment name	
number	9
Mode	0
	P-out/ eff.
Pout or ratio psia	16.0000
Comp. or Exp. type	Adiabatic
Efficiency	0.850000
Work	
Actual Kw	85712.9
Theor. Kw	72856.0
Cp/Cv	1.32234

Expander Summary

Page 6

Equipment name	
number	1
Mode	0
	P-out/ eff.
Pout or ratio psia	16.0000
Comp. or Exp. type	Adiabatic
Efficiency	0.880000
Work	
Actual Kw	-42786.5
Theor. Kw	-48621.0
Cp/Cv	1.42819

STREAM PROPERTIES

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Stream No.	1	2	3	4
Name	AIR			
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	Feed	12	12	2
To Eqp #	12	2	8	11
lbmol/hr	267165.	228268.	38896.8	228268.
Temp F	840.000	840.000	840.000	678.802
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.378564E+07	0.323449E+07	551154.	0.296221E+07
Cp Vap Btu/lb-R	0.257797	0.257797	0.257796	0.253381
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.9510	28.9510	28.9510	28.9510
- - Vapor only - -				
lb/hr	0.773470E+07	0.660860E+07	0.112610E+07	0.660860E+07
Std Vap ft3/hr	0.101383E+09	0.866230E+08	0.147605E+08	0.866230E+08
Actual ft3/hr	0.249358E+08	0.213054E+08	0.363042E+07	0.186665E+08
lb/ft3	0.310185	0.310185	0.310185	0.354034
Cp/Cv	1.36570	1.36570	1.36569	1.37606
Compress. factor	1.00393	1.00393	1.00393	1.00412
Th cond Btu/hr-ft-F	0.306373E-01	0.306373E-01	0.306373E-01	0.277152E-01
Visc cp	0.341087E-01	0.341087E-01	0.341087E-01	0.313364E-01

Stream No.	5	6	7	8
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	11	11	3	6
To Eqp #	6	3	16	15
lbmol/hr	141259.	87009.1	87009.1	141259.
Temp F	678.624	678.624	258.497	114.000
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.183310E+07	0.112910E+07	866116.	0.126213E+07
Cp Vap Btu/lb-R	0.253427	0.253409	0.244338	0.243380
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.9510	28.9510	28.9510	28.9510
- - Vapor only - -				
lb/hr	0.408960E+07	0.251900E+07	0.251900E+07	0.408960E+07
Std Vap ft3/hr	0.536049E+08	0.330181E+08	0.330181E+08	0.536049E+08
Actual ft3/hr	0.115496E+08	0.711401E+07	0.448212E+07	0.579284E+07
lb/ft3	0.354090	0.354090	0.562011	0.705975
Cp/Cv	1.37635	1.37625	1.40614	1.41917
Compress. factor	1.00412	1.00412	1.00273	0.999318
Th cond Btu/hr-ft-F	0.277119E-01	0.277119E-01	0.197519E-01	0.171703E-01
Visc cp	0.313332E-01	0.313332E-01	0.229069E-01	0.194205E-01

STREAM PROPERTIES

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Stream No.	9	10	11	12
Name				
Phase	Vapor	Vapor	Vapor	Vapor
From Eqp #	18	8	16	15
To Eqp #	15	16	18	5
lbmol/hr	125906.	38896.8	125906.	267165.
Temp F	113.714	258.130	258.497	113.838
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.112460E+07	387091.	0.125321E+07	0.238673E+07
Cp Vap Btu/lb-R	0.243386	0.244355	0.244370	0.243367
Mol Fraction Vapor	1.00000	1.00000	1.00000	1.00000
Average Mol Wt	28.9510	28.9510	28.9510	28.9510
- - Vapor only - -				
lb/hr	0.364510E+07	0.112610E+07	0.364510E+07	0.773470E+07
Std Vap ft3/hr	0.477786E+08	0.147605E+08	0.477786E+08	0.101383E+09
Actual ft3/hr	0.516059E+07	0.200266E+07	0.648582E+07	0.109529E+08
lb/ft3	0.706334	0.562301	0.562011	0.706178
Cp/Cv	1.41924	1.40629	1.40632	1.41911
Compress. factor	0.999307	1.00273	1.00273	0.999312
Th cond Btu/hr-ft-F	0.171657E-01	0.197450E-01	0.197519E-01	0.171677E-01
Visc cp	0.194132E-01	0.228986E-01	0.229069E-01	0.194164E-01

Stream No.	15	17	18	19
Name				
Phase	COOL AIR	slush water		
From Eqp #	Vapor	Liquid	Liquid	Liquid
To Eqp #	5	Feed	13	13
lbmol/hr	Product	13	10	7
Temp F	267165.	55493.9	24972.3	30521.6
Pres psia	70.0000	-39.4500	-39.4500	-39.4500
Enth KBtu /hr	150.000	14.7000	14.7000	14.7000
Cp Vap Btu/lb-R	0.230424E+07	-651403.	-293131.	-358272.
Cp Liq Btu/lb-R	0.243565			
Mol Fraction Vapor		1.00480	1.00480	1.00480
Average Mol Wt	1.00000	0.000000E+00	0.000000E+00	0.000000E+00
- - Liquid only - -	28.9510	18.0200	18.0200	18.0200
lb/hr		0.100000E+07	450000.	550000.
Std Liq gal/min		1998.93	899.521	1099.41
Sp Gr		0.999212	0.999212	0.999212
Actual gal/min		1888.71	849.921	1038.79
lb/gal		8.82363	8.82363	8.82363
Sf tens dyne/cm		83.2230	83.2230	83.2230
Th cond Btu/hr-ft-F		0.278042	0.278042	0.278042
Visc cp		6.62939	6.62939	6.62939
- - Vapor only - -				
lb/hr				
Std Vap ft3/hr	0.773470E+07			
Actual ft3/hr	0.101383E+09			
lb/ft3	0.100952E+08			
Cp/Cv	0.766177			
Compress. factor	1.42398			
Th cond Btu/hr-ft-F	0.997288			
Visc cp	0.165043E-01			
	0.182733E-01			

STREAM PROPERTIES

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CHEMCAD 2 - Version 2.5

Stream No.	20	22	23	24
Name				
Phase	Liquid	Mixed	Vapor	Vapor
From Eqp #	10	5	6	9
To Eqp #	18	6	9	Product
lbmol/hr	24972.3	30521.6	30521.6	30521.6
Temp F	-36.0110	70.0058	123.594	1221.19
Pres psia	1000.00	0.256300	0.256300	16.0000
Enth KBtu /hr	-291576.	-275779.	295186.	587833.
Cp Vap Btu/lb-R		0.481625	0.447360	0.532829
Cp Liq Btu/lb-R	1.00480	1.00495		
Mol Fraction Vapor	0.000000E+00	0.379586E-01	1.00000	1.00000
Average Mol Wt	18.0200	18.0200	18.0200	18.0200
- - Liquid only - -				
lb/hr	450000.	529123.		
Std Liq gal/min	899.521	1057.68		
Sp Gr	0.999212	0.999212		
Actual gal/min	852.240	1063.57		
lb/gal	8.79963	8.29094		
Sf tens dyne/cm	82.8916	72.7743		
Th cond Btu/hr-ft-F	0.280856	0.349818		
Visc cp	6.11796	0.986423		
- - Vapor only - -				
lb/hr		20877.2	550000.	550000.
Std Vap ft3/hr		439648.	0.115823E+08	0.115823E+08
Actual ft3/hr		0.256838E+08	0.745128E+09	0.343926E+08
lb/ft3		0.812856E-03	0.738128E-03	0.159918E-01
Cp/Cv		1.43215	1.32234	1.25097
Compress. factor		0.999724	0.999785	0.999648
Th cond Btu/hr-ft-F		0.102035E-01	0.115782E-01	0.512619E-01
Visc cp		0.892102E-02	0.100985E-01	0.355016E-01

STREAM PROPERTIES

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CHEMCAD 2 - Version 2.5

Stream No.	25	26	27	28
Name				
Phase	Mixed	Vapor	Mixed	Vapor
From Eqp #	3	2	1	8
To Eqp #	2	1	8	Product
lbmol/hr	24972.3	24972.3	24972.3	24972.3
Temp F	541.689	830.000	221.432	830.000
Pres psia	1000.00	1000.00	16.0000	16.0000
Enth KBtu /hr	100017.	372297.	226212.	390275.
Cp Vap Btu/lb-R	-.285433	0.595200	0.495979	0.498133
Cp Liq Btu/lb-R	1.26986		1.00409	
Mol Fraction Vapor	0.401605	1.00000	0.925272	1.00000
Average Mol Wt	18.0200	18.0200	18.0200	18.0200
- - Liquid only - -				
lb/hr	269278.		33627.6	
Std Liq gal/min	538.269		67.2193	
Sp Gr	0.999212		0.999212	
Actual gal/min	776.199		73.6602	
lb/gal	5.78151		7.60809	
Sf tens dyne/cm	18.2333		57.6127	
Th cond Btu/hr-ft-F	0.336220		0.394764	
Visc cp	0.942673E-01		0.264162	
- - Vapor only - -				
lb/hr	180722.	450000.	416372.	450000.
Std Vap ft3/hr	0.380578E+07	0.947644E+07	0.876828E+07	0.947644E+07
Actual ft3/hr	84884.3	319355.	0.104603E+08	0.215728E+08
lb/ft3	2.12904	1.40909	0.398049E-01	0.208596E-01
Cp/Cv	-.629754	1.42819	1.42443	1.28067
Compress. factor	0.787738	0.924138	0.991120	0.998830
Th cond Btu/hr-ft-F	0.242474E-01	0.818530E-01	0.142356E-01	0.348812E-01
Visc cp	0.208297E-01	0.271058E-01	0.122862E-01	0.263639E-01

Stream No.	29	30
Name		
Phase	Liquid	Liquid
From Eqp #	7	18
To Eqp #	5	3
lbmol/hr	30521.6	24972.3
Temp F	-39.4500	248.497
Pres psia	0.256300	1000.00
Enth KBtu /hr	-358272.	-162968.
Cp Liq Btu/lb-R	1.00480	1.00363
Mol Fraction Vapor	0.000000E+00	0.000000E+00
Average Mol Wt	18.0200	18.0200
- - Liquid only - -		
lb/hr	550000.	450000.
Std Liq gal/min	1099.41	899.521
Sp Gr	0.999212	0.999212
Actual gal/min	1038.78	999.723
lb/gal	8.82373	7.50147
Sf tens dyne/cm	83.2230	54.6961
Th cond Btu/hr-ft-F	0.278042	0.397011
Visc cp	6.62939	0.228185

FLOW SUMMARIES

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CHEMCAD 2 - Version 2.5

Stream No.	1	2	3	4
Name	AIR			
Temp F	840.000	840.000	840.000	678.802
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.378564E+07	0.323449E+07	551154.	0.296221E+07
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	267165.	228268.	38896.8	228268.
Flowrates in lbmol/hr				
Air	267165.	228268.	38896.8	228268.
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	5	6	7	8
Name				
Temp F	678.624	678.624	258.497	114.000
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.183310E+07	0.112910E+07	866116.	0.126213E+07
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	141259.	87009.1	87009.1	141259.
Flowrates in lbmol/hr				
Air	141259.	87009.1	87009.1	141259.
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	9	10	11	12
Name				
Temp F	113.714	258.130	258.497	113.838
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.112460E+07	387091.	0.125321E+07	0.238673E+07
Vapor mole fraction	1.00000	1.00000	1.00000	1.00000
Total lbmol/hr	125906.	38896.8	125906.	267165.
Flowrates in lbmol/hr				
Air	125906.	38896.8	125906.	267165.
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	15	17	18	19
Name	COOL AIR	slush water		
Temp F	70.0000	-39.4500	-39.4500	-39.4500
Pres psia	150.000	14.7000	14.7000	14.7000
Enth KBtu /hr	0.230424E+07	-651403.	-293131.	-358272.
Vapor mole fraction	1.00000	0.000000E+00	0.000000E+00	0.000000E+00
Total lbmol/hr	267165.	55493.9	24972.3	30521.6
Flowrates in lbmol/hr				
Air	267165.	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	55493.9	24972.3	30521.6
Stream No.	20	22	23	24
Name				
Temp F	-36.0110	70.0058	123.594	1221.19
Pres psia	1000.00	0.256300	0.256300	16.0000
Enth KBtu /hr	-291576.	-275779.	295186.	587833.
Vapor mole fraction	0.000000E+00	0.379586E-01	1.00000	1.00000
Total lbmol/hr	24972.3	30521.6	30521.6	30521.6
Flowrates in lbmol/hr				
Air	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	24972.3	30521.6	30521.6	30521.6

FLOW SUMMARIES

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Stream No.	25	26	27	28
Name				
Temp F	541.689	830.000	221.432	830.000
Pres psia	1000.00	1000.00	16.0000	16.0000
Enth KBtu /hr	100017.	372297.	226212.	390275.
Vapor mole fraction	0.401605	1.00000	0.925272	1.00000
Total lbmol/hr	24972.3	24972.3	24972.3	24972.3
Flowrates in lbmol/hr				
Air	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	24972.3	24972.3	24972.3	24972.3

Stream No.	29	30
Name		
Temp F	-39.4500	248.497
Pres psia	0.256300	1000.00
Enth KBtu /hr	-358272.	-162968.
Vapor mole fraction	0.000000E+00	0.000000E+00
Total lbmol/hr	30521.6	24972.3
Flowrates in lbmol/hr		
Air	0.000000E+00	0.000000E+00
Water	30521.6	24972.3

FLOW SUMMARIES

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CHEMCAD 2 - Version 2.5

Stream No.	1	2	3	4
Name	AIR			
Temp F	840.000	840.000	840.000	678.802
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.378564E+07	0.323449E+07	551154.	0.296221E+07
Vapor mass fraction	1.00000	1.00000	1.00000	1.00000
Total lb/hr	0.773470E+07	0.660860E+07	0.112610E+07	0.660860E+07
Flowrates in lb/hr				
Air	0.773470E+07	0.660860E+07	0.112610E+07	0.660860E+07
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	5	6	7	8
Name				
Temp F	678.624	678.624	258.497	114.000
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.183310E+07	0.112910E+07	866116.	0.126213E+07
Vapor mass fraction	1.00000	1.00000	1.00000	1.00000
Total lb/hr	0.408960E+07	0.251900E+07	0.251900E+07	0.408960E+07
Flowrates in lb/hr				
Air	0.408960E+07	0.251900E+07	0.251900E+07	0.408960E+07
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	9	10	11	12
Name				
Temp F	113.714	258.130	258.497	113.838
Pres psia	150.000	150.000	150.000	150.000
Enth KBtu /hr	0.112460E+07	387091.	0.125321E+07	0.238673E+07
Vapor mass fraction	1.00000	1.00000	1.00000	1.00000
Total lb/hr	0.364510E+07	0.112610E+07	0.364510E+07	0.773470E+07
Flowrates in lb/hr				
Air	0.364510E+07	0.112610E+07	0.364510E+07	0.773470E+07
Water	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Stream No.	15	17	18	19
Name	COOL AIR	slush water		
Temp F	70.0000	-39.4500	-39.4500	-39.4500
Pres psia	150.000	14.7000	14.7000	14.7000
Enth KBtu /hr	0.230424E+07	-651403.	-293131.	-358272.
Vapor mass fraction	1.00000	0.000000E+00	0.000000E+00	0.000000E+00
Total lb/hr	0.773470E+07	0.100000E+07	450000.	550000.
Flowrates in lb/hr				
Air	0.773470E+07	0.000000E+00	0.000000E+00	0.000000E+00
Water	0.000000E+00	0.100000E+07	450000.	550000.
Stream No.	20	22	23	24
Name				
Temp F	-36.0110	70.0058	123.594	1221.19
Pres psia	1000.00	0.256300	0.256300	16.0000
Enth KBtu /hr	-291576.	-275779.	295186.	587833.
Vapor mass fraction	0.000000E+00	0.379586E-01	1.00000	1.00000
Total lb/hr	450000.	550000.	550000.	550000.
Flowrates in lb/hr				
Air	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	450000.	550000.	550000.	550000.

FLOW SUMMARIES

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CHEMCAD 2 - Version 2.5

Stream No.	25	26	27	28
Name				
Temp F	541.689	830.000	221.432	830.000
Pres psia	1000.00	1000.00	16.0000	16.0000
Enth KBtu /hr	100017.	372297.	226212.	390275.
Vapor mass fraction	0.401605	1.00000	0.925272	1.00000
Total lb/hr	450000.	450000.	450000.	450000.
Flowrates in lb/hr				
Air	0.000000E+00	0.000000E+00	0.000000E+00	0.000000E+00
Water	450000.	450000.	450000.	450000.

Stream No.	29	30
Name		
Temp F	-39.4500	248.497
Pres psia	0.256300	1000.00
Enth KBtu /hr	-358272.	-162968.
Vapor mass fraction	0.000000E+00	0.000000E+00
Total lb/hr	550000.	450000.
Flowrates in lb/hr		
Air	0.000000E+00	0.000000E+00
Water	550000.	450000.

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13. ABSTRACT (Maximum 200 words)

Several air breathing propulsion concepts for future earth-to-orbit transport vehicles utilize air collection and enrichment, and subsequent storage of liquid oxygen for later use in the vehicle mission. Work performed during the 1960's established the feasibility of operating the distillation elements in high "g" fields obtained by rotating the separator assembly.

The purpose of this study was to evaluate various fuels and fuel combinations with the objective of minimizing the weight and increase the ready alert capability of the plane. Fuel energy was used to provide power for air separation as well as to produce refrigeration for liquefaction of oxygen enriched air, besides it primary purpose of vehicle propulsion. The heat generated in the cycle was rejected to the fuel and water which is also carried on board the vehicle. The fuels that were evaluated include JP4, methane and hydrogen. Hydrogen served as a comparison to the JP4 and methane cases.

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